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PHYTOTOXICOLOGY SURVEY REPORT:

MOSS BAG SURVEYS

IN THE VICINITY OF

BENN IRON/EATON YALE

WALLACEBURG (1994)

JUNE 1996

Ontario

Ministry of
Environment
and Energy

ISBN 0-7778-5337-X

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MOSS BAG SURVEYS IN THE VICINITY OF

BENN IRON/EATON YALE

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Report prepared for:

Ontario Ministry of Environment and Energy

BACKGROUND and INTRODUCTION

In September, 1994 the Sarnia District Office of the Ministry of the Environment and Energy (MOEE) requested a survey in the vicinity of a number of iron die casters, aluminum die casters, and various metal forming and stamping plants in the western part of Wallaceburg. This section of the municipality is highly concentrated with a number of industries, including Benn Iron, Eaton Yale, Accurcast and Waltec Industries. The District office had received a number of complaints from residents and businesses concerning particulate emissions originating from the area. One of the complainants was the owner of a local car dealership that was having continuing problems with particulate fallout on new vehicles. The Sarnia Office responded to these complaints by initiating investigations that involved, amongst others, R. Brown (Environmental Officer) and R. Fosberg (Investigations and Enforcement - Investigator). The investigations were reported separately and included various field visits during which samples of particulate were collected from potential industrial sources and impacted properties.

The District Office requested the assistance of the Phytotoxicology Section to determine the extent and radial distribution of the contamination and to attempt to differentiate the sources. To accomplish these goals, a moss bag survey was initiated that involved three, one month exposure periods. This report summarizes the results of the three moss bag exposure periods (**October** - September 30, 1994 to October 31, 1994; **November** - October 31, 1994 to December 2, 1994; and **December** - December 2, 1994 to January 4, 1995).

METHODOLOGY

Meteorological Data

Wind data normals were obtained from the closest Environment Canada monitoring station (Sarnia - approximately 8 km NE of the centre of Sarnia) for the period from 1967 to 1980. In addition, hourly wind data were obtained and analyzed for the specific periods of moss bag exposures in 1994 and 1995.

Moss Bag Surveys

Moss has been used successfully by Phytotoxicology investigators to map zones of heavy metal contamination around point sources of air pollution. This is possible because of the absorption capacity of moss and its ability to sorb and retain airborne trace metals from wet and dry deposition. Small quantities of moss sewn into packets of nylon mesh are known as *moss bags* and have been employed by the Phytotoxicology Section for studying zones of atmospheric contamination around a range of industrial sources.

A network of 43 moss bag sites were established on September 30, 1994. The distribution of these sites is presented in Figure 1. Two of the sites are not illustrated in this map, as they were control sites located from 3 to 8 km away. Collections were made for the months of October (Sept. 30 - Oct. 31, 1994), November (Oct. 31 - Dec.2, 1994) and December (Dec. 2, 1994 - Jan. 4, 1995). Exposed moss bags were collected from all sites on the indicated dates and replaced

with un-exposed bags for the following exposure. Duplicate bags were exposed for each period at each site.

Moss bag samples were transported in paper bags, then oven-dried and processed in the Phytotoxicology Laboratory using standard procedures[1]. Six (6) replicate samples of un-exposed moss bags (each replicate containing several individual moss bags) were also processed and analyzed along with each of the exposure submissions for comparative purposes. Samples were stored in glass bottles. The processed samples were then forwarded to the Ministry of Environment and Energy laboratory in Etobicoke for chemical analysis. Analyses were conducted for total aluminum (Al), beryllium (Be), barium (Ba), boron (B), calcium (Ca), cadmium (Cd), cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), strontium (Sr), vanadium (V), and zinc (Zn).

Data Analysis, Presentation and Interpretation

Inorganic elemental concentrations in moss bags were compared to the MOEE Upper Limit of Normal (ULN) contaminant guidelines for moss (where available) to assess the degree of contamination[2]. The ULNs represent the maximum expected concentrations of selected elements in moss bags in the absence of a point source of air pollution (Appendix I).

Contour maps were produced from the moss bag chemistry data using *Surfer Version 4* (options: Kriging with normal search method for as many points as possible, smoothing with a tension factor of 2, and grid size of 50 by 50). These maps are statistical approximations of the spatial distribution of the different contaminants. The contours produced by the program are significantly affected by the spatial distribution of the sampling sites, the accuracy of the positional information of the sampling sites, and the program options used to generate the contours. The accuracy of the contours diminishes at the edges of the map and in large areas where there are no sampling sites. The maps should, therefore, only be used to provide information on approximate areas and/or patterns of contamination and cannot be used to infer concentrations of contaminants at locations not directly sampled.

RESULTS

The results of the chemical analysis for 18 inorganic elements in moss are summarized in the attached tables (Table 1 - October, Table 2 - November and Table 3 - December). Approximate distances and directions of the sites are given relative to a point on Arnold Street directly between Eaton Yale Ltd. and Benn Iron Foundry. The elements are listed in alphabetical order. Also listed in the tables are the Phytotoxicology Section ULN guidelines (where available) for moss bags, in urban and rural areas of Ontario. Levels exceeding the urban ULNs or the rural ULN where an urban guideline is not available, have been indicated in bold and underlined. Appendix II contains a series of contour maps for inorganic elements in moss bags collected in the vicinity of the foundries for the 3 collection periods.

Wind normals for the months of October through December are illustrated in Figure 2. This data indicates a strong tendency toward winds from the S (S and SSW) and from the W (W

and WSW) during the fall. Wind data for the specific periods covering the moss bag exposures are illustrated in Figures 3. Generally, the 1994 wind data show similar wind patterns to the normals for the same months. While the general trend toward predominantly S and W winds occurred for each of the exposure periods, there was a tendency for winds during the December collection period to be more evenly distributed across the cardinal directions (i.e., winds from the N, NW, SE and ESE were strongly represented).

The urban (or substitute rural) ULNs for moss bags were commonly exceeded in this study for Al and Fe, with occasional exceedences for Ni, Cr and Zn. The exceedences for Al and Fe were numerous for the October and November collection periods (5 and 9 Stations respectively for Al, and 3 and 5 Stations respectively for Fe). However, there were no exceedences for Al in the December collection and only 1 exceedence for Fe in the same collection period. Ni, Cr and Zn each exceeded the ULN at single, albeit different, stations in one of the collection periods.

Concentrations of Fe in moss at collection sites near the centre of the study area tended to be higher than those located more distant. The contour maps for Fe in moss for each of the collection periods (Figure 12) indicate clear patterns of Fe deposition to moss bags around Benn Iron and Eaton Yale. In October, there was a cluster of contours that centred in the immediate NE vicinity of Benn Iron and just E of Eaton Yale. This clustering, indicating higher concentrations of Fe in moss. was skewed in a SW to NE direction. The area with predicted Fe concentrations in moss exceeding 2350 µg/g extended to Forham St. to the E. Arnold St. to the W and approximately 175 m N of the Benn Iron property line. A secondary 2350 µg/g contour was centred in the vicinity of the car dealership to the north. The area with predicted concentrations exceeding the urban ULN (3000 µg/g) also extended along prevailing wind directions more than 1000 m to the N. The pattern was similar for November except that the concentrations of Fe in the vicinity of the foundries were higher and the contamination extended further and to the ENE. Although, as indicated above, concentrations of Fe in moss collected in the vicinity were much lower in December than either of the other two months, there was still a discernable concentration gradient around the area. Concentrations of Fe exceeding 2350 µg/g were found at stations immediately adjacent to the Benn Iron foundry to the N and NE in December.

Contour patterns similar to those determined for Fe were found for Al, Cd, Co, Cr, Cu, Mo and Zn. In the case of Al (Figure 4), concentrations in excess of the rural ULN (no urban ULN is available) were found within 350 m of the centre point of the study area in October. As with Fe, clusters of contours indicating areas of highest contamination were found in the vicinity of Benn Iron and E of Eaton Yale. A secondary area of elevated Al concentrations in moss was also found centred to the N in the vicinity of the car dealership (immediately ENE of Accuracast Die Casting). The pattern was similar for November except that the concentrations of Al in the vicinity of the foundries were higher and the contamination extended further and to the NE. Although, as indicated above, concentrations of Al in moss collected in the vicinity of the foundries were much lower in December than either of the other two months, there was still a discernable concentration gradient around the foundries.

There were no exceedences of the ULN for Co (Figure 9). However, moss bags to the NE of Benn Iron were notably elevated in Co during October and November. Similarly, Co concentrations in October were elevated in moss to the ENE of Accuracast in the vicinity of the

car dealership. As with the other metals examined, the concentrations of Co in moss were considerably lower for the month of December and the source-related gradient was extremely weak.

Although there was only one exceedence of the Cr ULN for moss, there were definite trends toward higher concentrations closer to the centre of the study area. For Cr (Figure 11), in October and November, the central area of contamination extended further to the W (towards Eaton Yale) and extended as one contiguous area N to the area of Accuracast and the car dealership. The pattern for December was weak. Concentration contours for Cd (Figure 8) and Mo (Figure 15) were similar to those for Cr and indicated that all three industries in the area were likely contributing these metals to the local environment in October and November. Contaminant contours suggest that Accuracast and Waltec may have been weak sources of Cd and Mo, respectively, in the month of December.

The central zone of contamination for Zn in October (Figure 20) was concentrated in the immediate vicinity of Benn Iron. While concentrations for Zn tended to be higher in November and December, Benn Iron and Eaton Yale could not be solely implicated for these two periods. In November, an area of elevated Zn was found immediately to the N of Benn Iron and Eaton Yale. however, an area of higher concentrations occurred adjacent to Waltec in both November and December.

Elevated Cu concentrations (Figure 10) were also found in the general area of the industries and extending to the N. However, the zones of highest Cu concentration occurred further to the N and extended more to the to the S and E than Fe, Al, Cr and Zn. As with other metals, Cu concentrations in moss tended to be higher in November than in the other months. The highest Cu concentrations consistently occurred at moss bag sites adjacent to Waltec.

Other metals for which zones of elevated metal concentrations were identifiable included Ba (Figure 6), Ca (Figure 7), Mn (Figure 14), Ni (Figure 16) and Sr (Figure 18). However, in the case of Ba and Mn, the zones of maximum concentrations within the mapped study area were comparable to the concentrations in the control areas suggesting that contributions from industries in the area may result in concentrations in moss that are only slightly above local background. This was also the case for Sr and Ca in all months except November when there were slightly elevated concentrations of these elements in the vicinity of the industries and extending to the north. As indicated above, Ni concentrations exceeded the ULN at one site (Site 19) in October. Because of the location of this site (adjacent to the rail tracks ENE of Benn Iron), the patterns of Ni in moss in the study area, and the fact that similar concentrations did not occur in the other periods, it is probable that this single elevated concentration is an anomaly and not likely related to emissions from local industries.

There were a number of elements for which contour mapping did not suggest a deposition pattern associated with industries in the area. These included B, Mg, Pb and V. Elevated boron concentrations to the N of the industries likely resulted from emissions from Libby-St.Clair. No contour mapping was generated for Be in moss because all of the survey data were below the analytical detection limit.

SUMMARY AND CONCLUSIONS

A number of observations involving the results of moss bag analysis in the vicinity of Mason and Arnold Streets in Wallaceburg indicated that industries in the area are emitting Al, Cd, Co, Cr, Cu, Fe, Zn and to a lesser extent, Mo and Ni. Concentrations of these elements at sample sites near to the centre of the study area and/or those located downwind were consistently elevated relative to those upwind and distant from the central area. For each of these metals, the zones of highest contamination were found in the general area encompassed by Benn Iron, Eaton Yale and to a lesser extent Accuracast and Waltec. Fe was particularly elevated in the study area and was the element presenting the strongest source-related deposition pattern. Concentrations in the immediate vicinity of Benn Iron may have been additionally elevated as the result of fugitive emissions from foundry sand and other debris in the north yard. Concentrations of most elements, including Fe and Al, were lower in moss in December than in either November or December. This moss bag chemistry information may be used with characteristic baghouse chemical profiles to help differentiate between the contributions of the possible sources in the area.

REFERENCES

1. Ontario Ministry of the Environment. 1983. Field investigations manual: Technical Support Sections-NE and NW Regions. Phytotoxicology Section, Air Resources Branch, MOE.

2. Ontario Ministry of the Environment. 1989. Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxicology Samples - March 1989. ARB-138-88-PHYTO. Phytotoxicology Section -Air Resources Branch. MOE.

Table 1: Concentrations of elements in moss bags collected in the vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994).

Site	DISTANCE (m) and DIRECTION (approx.)		Inorganic Elements in Moss Bags (µg/g)																
			Al	Be	Ba	B	Ca	Cd	Co	Cu	Cr	Fe	Mg	Mn	Mo	Ni	Pb	Sr	V	Zn
22	25 m	N	1500	0.2 W	40	8.3	15000	0.51T	0.81 T	20	8.8	2500	1400	170	0.85 T	5.8	28	23	6.2	220
18	100 m	N	1400	0.2 W	42	9.4	16000	0.44 T	0.81 T	30	8.5	2700	1400	240	1.1	6.1	35	23	7.1	215
11	225 m	N	1300	0.2 W	39	8.2	9200	0.55	0.78 T	22	5.3	2000	1400	190	0.69 T	5.7	24	18	8.0	160
7	300 m	N	1700	0.2 W	39	10.0	11000	0.49	1.2	20	5.8	2300	1600	180	0.98	8.8	33	21	7.5	150
3	600 m	N	1600	0.2 W	37	10.2	14000	0.29 T	0.88 T	20	4.5	2000	1900	190	0.80 T	7.2	30	20	7.5	101
1	1000 m	N	1800	0.2 W	38	14.0	10000	0.38 T	0.85 T	13	4.5	1700	1800	200	0.54 T	7.3	26	18	7.1	96
8	350 m	NNE	**2300**	0.2 W	41	9.2	7800	0.42 T	1.3	14	5.2	2800	1500	200	0.54 T	5.4	33	18	8.9	130
17	100 m	NE	**1800**	0.2 W	38	8.0	9000	0.62	1.2	14	5.4	**4100**	1400	210	0.91 T	7.8	40	24	8.8	210
18	200 m	NE	1400	0.2 W	34	8.4	8100	0.40T	0.78 T	10	4.0	2200	1100	230	0.80 T	4.8	25	15	8.1	140
12	250 m	NE	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
13	350 m	NE	1800	0.2 W	31	8.9	4800	0.35 T	0.98 T	9	3.7	1900	1100	190	0.39 T	5.1	29	12	7.1	88
9	450 m	NE	1600	0.2 W	38	10.6	7400	0.40 T	0.80T	13	4.3	2000	1400	180	0.50 T	7.0	32	18	7.9	190
2	900 m	NE	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
14	350 m	ENE	1800	0.2 W	33	9.8	11000	0.38 T	0.95 T	13	4.3	2200	1600	190	0.37 T	5.2	27	19	7.5	150
24	75 m	E	**2300**	0.2 W	42	7.0	7400	0.65	1.1	13	5.6	**4000**	1400	200	0.87 T	6.1	40	23	7.3	320
25	150 m	E	**2000**	0.2 W	41	9.1	13000	0.90	1.6	17	5.7	**5100**	1700	280	1.1	7.1	37	25	8.1	390
19	300 m	E	1700	0.2 W	35	12.0	9400	0.45 T	0.98 T	14	4.5	2100	1500	180	0.62 T	**18**	37	18	7.5	180
20	500 m	E	1100	0.2 W	33	5.8	4200	0.32 T	0.43 T	8	2.9	1300	1000	100	0.42 T	3.8	28	11	5.9	73
21	900 m	E	1300	0.2 W	48	8.2	7900	0.40 T	0.88 T	7	3.1	1500	1400	180	0.58 T	3.8	24	17	8.1	82
26	350 m	ESE	**2200**	0.2 W	40	7.2	5700	0.45 T	1.0	11	5.3	2500	1300	220	0.80 T	8.2	38	13	8.9	140
31	300 m	SE	1500	0.2 W	48	8.8	8300	0.33 T	0.93 T	11	4.2	1800	1500	250	0.48 T	4.3	24	18	5.9	101
32	450 m	SE	1800	0.2 W	34	8.3	8500	0.44 T	0.73 T	13	3.5	1700	1100	150	0.44 T	4.7	38	14	8.2	285
37	800 m	SE	1100	0.2 W	33	8.3	8000	0.33 T	1.2	7	3.1	1100	1100	180	0.34 T	3.5	18	13	5.0	80
30	200 m	SSE	1500	0.2 W	44	8.3	6600	0.29 T	0.90 T	30	4.4	1700	1200	240	0.80 T	4.4	18	15	6.0	215
33	300 m	SSE	1500	0.2 W	40	7.4	8300	0.31 T	0.90 T	7	3.8	1700	1600	200	0.29 T	3.8	28	19	5.9	100
36	400 m	SSE	1100	0.2 W	31	7.7	7700	0.33 T	0.33 T	8	2.8	1400	1100	150	0.38 T	3.8	42	15	5.5	78
40	900 m	SSE	900	0.2 W	27	4.8 T	5100	0.34 T	0.50 T	14	2.2 T	1000	900	90	0.45 T	3.8	21	12	4.7	210
23	26 m	S	1190	0.2 W	33	5.2	5700	0.39 T	0.48 T	14	4.2	1700	1000	200	0.62 T	4.1	25	13	5.7	150
29	100 m	S	1400	0.2 W	37	8.2	8100	0.40 T	0.70 T	23	3.7	1700	1100	200	0.57 T	4.3	31	13	8.7	180
35	350 m	S	1200	0.2 W	30	9.7	5400	0.32 T	0.52 T	8	2.7 T	1200	1000	170	0.53 T	7.3	21	13	5.4	85
39	875 m	S	1500	0.2 W	36	8.8	5900	0.33 T	0.71 T	8	4.2	1500	1300	130	0.42 T	4.4	25	15	8.5	68
41	1000 m	S	800	0.2 W	32	4.3 T	2800	0.33 T	0.28 T	5	1.8 T	900	700	140	0.27 T	3.1	19	9	4.7	48
28	200 m	SW	1600	0.2 W	43	8.8	6500	0.27 T	0.84 T	15	3.9	1800	1400	230	0.56 T	4.0	19	18	8.1	130
34	400 m	SW	900	0.2 W	34	5.9	6100	0.24 T	0.48 T	7	2.1 T	1100	1000	190	0.40 T	3.0	18	12	4.7	80
38	700 m	SW	1000	0.2 W	34	6.2	6700	0.18 T	0.52 T	6	2.4 T	1200	1100	200	0.50 T	3.2	20	14	5.2	68
27	300 m	WSW	1400	0.2 W	39	8.4	9800	0.20 T	0.79	21	3.6	1700	1300	210	0.46 T	3.6	18	19	5.5	210
15	300 m	W	1400	0.2 W	50	7.7	8800	0.30T	0.76 T	9	4.4	1700	1400	260	0.81 T	3.8	15	18	4.9	94
10	250 m	NW	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5	450 m	NW	1200	0.2 W	32	7.0	4400	0.38 T	0.35 T	7	2.9	1200	1000	130	0.38 T	5.8	27	12	7.2	91
4	700 m	NW	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
6	350 m	NNW	1700	0.2 W	38	11.0	7500	0.42 T	0.88 T	14	4.9	1800	1600	200	0.83 T	9.9	22	17	6.8	86
42	3000 m	S	1100	0.2 W	32	6.9	14000	0.27 T	0.73 T	6	2.7	1400	1500	180	0.88 T	3.6	20	28	5.4	53
43	8000 m	S	1500	0.2 W	42	7.3	8400	0.33 T	0.77 T	6	3.1	1500	1800	220	0.43 T	3.1	23	18	5.9	82
BLANKS			1250	0.2 W	40	3.9	3200	0.40 T	0.84 T	5	2.4	1200	1100	190	0.38 T	2.6	28	13	5.1	48
ULN (Urban)			1700	NG	NG	NG	NG	NG	8	80	7	3000	NG	NG	NG	13	200	NG	NG	800

Concentrations in bold and underlined exceed the urban ULN (or rural ULN where an urban guideline is not available. NG - no guideline nd - no data

W - detection limit

T - trace amount, interpret with caution

Table 2: Concentrations of elements in moss bags collected in the vicinity of Benn Iron and Eaton-Yale, Wallaceburg (November 1994).

Site	DISTANCE (m) and DIRECTION (approx.)		Inorganic Elements in Moss Bags (µg/g)																
			Al	Be	Ba	B	Ca	Cd	Co	Cu	Cr	Fe	Mg	Mn	Mo	Ni	Pb	Sr	V	Zn
22	25 m	N	1650	DL	42	7.5	17000	0.63	0.65T	26	6.5	3100	1400	165	0.99T	5.4	34	26	6.7	265
15	100 m	N	2100	DL	53	10.5	16000	0.75	1.3	39	15	5400	1700	255	1.7	9	33	27	7.4	455
11	225 m	N	1350	DL	42	8.6	8400	0.56T	0.47T	18	5.1	1750	1200	230	0.60T	4.7	21	14	6.5	165
7	360 m	N	1450	DL	49	7.5	10100	0.60T	0.64T	18	5.7	2100	1350	205	0.71T	5.8	26	17	6.4	170
3	800 m	N	2300	DL	44	14.5	16500	0.70	1.2	32	5.6	2750	2100	215	0.86T	11	50	24	9.9	150
1	1000 m	N	1400	DL	39	7.7	9100	0.51T	0.73T	13	4.1	1750	1500	175	0.87T	9	42	18	7.1	113
8	350 m	NNE	1450	DL	48	8.2	8700	0.50T	.84T	14	4.5	1800	1150	185	0.63T	5.5	28	15	6.9	185
17	100 m	NE	1650	DL	36	7.9	7600	0.64	0.82T	12	4.9	2650	1250	185	0.81T	6.3	27	20	6.1	200
16	200 m	NE	2100	DL	42	7.3	10000	0.94	1.55	17	6.4	4950	1450	215	0.77T	8.1	41	25	8.7	515
12	250 m	NE	2400	DL	40	10.8	8600	0.62	1.3	19	8.8	3900	1450	180	0.82T	8.8	50	22	7.9	335
13	350 m	NE	2000	DL	38	6.4T	5600	0.61T	1.0T	11	4.7	2400	1200	165	0.50T	10	45	15	7.5	160
9	450 m	NE	2300	DL	44	14.6	16500	0.70	1.2	32	5.8	2750	2100	215	0.86T	11	50	24	9.8	150
2	900 m	NE	1400	DL	37	8.6	4000	0.49T	0.66T	11	3.6	1450	890	160	0.48T	9.8	38	12	7.8	140
14	350 m	ENE	2000	DL	40	10.5	13000	0.57T	1.1T	17	5.0	2800	1700	195	0.70T	8.3	33	23	8.6	240
24	75 m	E	2200	DL	36	8.4	10300	0.83	1.3T	15	5.9	4350	1550	215	0.90T	7.8	36	23	8.6	390
5	100 m	E	1800	DL	35	5.0T	5100	0.57	0.97T	18	4.5	1850	1150	185	0.55T	5.0	43	12	8.9	98
19	300 m	E	1350	DL	32	5.9T	8200	0.46T	0.75T	12	3.7	2050	1100	160	0.51T	7.4	28	14	5.3	260
20	500 m	E	1300	DL	36	4.9T	5100	0.39T	0.68T	11	3.2	1550	1000	170	0.38T	3.7	33	15	5.8	110
21	900 m	E	1250	DL	49	5.2T	9300	0.56	0.59T	9	3.3	1580	1300	165	0.48T	4.0	37	18	8.2	115
26	350 m	ESE	1850	DL	36	8.3	10500	0.74	1.0T	26	4.4	2800	1500	175	0.82T	5.5	39	20	7.0	310
31	360 m	SE	1450	DL	36	8.3	14500	0.80T	1.1T	23	4.5	2250	1400	200	0.61T	4.9	34	20	8.3	175
32	450 m	SE	1160	DL	40	4.6T	8300	0.56	0.57T	26	2.7	1300	1200	170	0.45T	3.6	40	18	8.6	640
37	600 m	SE	1500	DL	42	4.8T	6200	0.44T	0.56T	11	3.3	1550	1150	180	0.41T	4.7	36	15	6.3	93
30	200 m	SSE	1250	DL	38	5.8T	7800	0.47T	0.63T	77	5.3	1650	1150	175	1.09T	6.5	26	14	5.5	250
33	300 m	SSE	1450	DL	33	4.6T	6800	0.54	0.64T	10	3.7	1850	1100	180	0.35T	4.7	43	13	7.0	125
36	400 m	SSE	1350	DL	36	6.0	11500	0.48T	0.60T	18	3.8	1850	1250	175	0.55T	5.2	43	17	8.9	140
40	900 m	SSE	1200	DL	40	3.5T	4200	0.40T	0.37T	11	2.6T	1200	930	205	0.31T	3.2	34	11	6.8	122
23	25 m	S	1230	DL	37	5.5T	7800	0.39T	0.54T	19	4.1	2050	1050	220	0.76T	4.1	29	14	6.3	215
29	100 m	S	1350	DL	33	5.8	6600	0.41T	0.63T	20	3.7	1550	1100	210	0.61T	4.0	27	14	5.9	145
35	350 m	S	1400	DL	38	7.7	8200	0.48T	0.60T	10	3.1	1550	1080	130	0.47T	3.8	45	17	6.5	120
39	875 m	S	1450	DL	38	8.5	4500	0.46T	0.35T	7	3.5	1400	1100	175	0.35T	4.2	41	13	7.3	85
41	1000 m	S	1450	DL	35	6.2T	3300	0.42T	0.44T	8	3.1	1800	910	155	0.30T	3.8	49	10	7.3	81
28	200 m	SW	1850	DL	36	5.4T	5600	0.61	0.78T	54	4.7	2050	1050	175	0.69T	6.1	55	16	8.3	140
34	400 m	SW	1450	DL	35	6.2T	6900	0.57	0.65T	10	3.6	1800	1050	180	0.55T	4.2	42	14	7.1	81
38	700 m	SW	1150	DL	35	4.3T	3500	0.37T	0.47T	6	2.7	1250	860	170	0.29T	3.6	28	12	5.9	67
27	300 m	WSW	1200	DL	38	6.2	13000	0.73T	0.85T	180	3.8	1450	1090	190	0.47T	4.2	32	16	6.2	260
15	300 m	W	1200	DL	38	6.2	4200	0.34T	0.54T	9	3.0	1350	970	185	0.38T	3.1	21	12	5.9	78
10	250 m	NW	1200	DL	36	3.9T	3700	0.45T	0.46T	13	3.9	1350	850	145	0.26T	2.8	23	11	5.2	89
5	450 m	NW	1800	DL	35	5.0T	6100	0.57	0.87T	19	4.6	1650	1150	185	0.55T	6.0	43	12	8.9	96
4	700 m	NW	1300	DL	32	4.2T	3800	0.45T	0.47T	6	3.0	1350	1030	190	0.27T	3.6	34	10	6.9	68
6	350 m	NNW	1250	DL	35	12.0	6500	0.56	0.48T	13	4.1	1350	1200	240	0.47T	7.1	18	14	5.2	105
42	3000 m	S	1600	DL	60	5.0T	8150	0.48 T	0.52 T	7	3.3	1550	1100	140	0.58 T	4.4	39	15	7.4	78
43	9000 m	S	1000	DL	38	2.6T	3800	0.42 T	0.37 T	7	1.6T	605	930	155	0.30 T	3.7	27	13	3.4	72
BLANKS			1200	DL	35	2.4T	2400	0.41 T	0.42 T	4.5	1.9	990	620	177	DL	2.7T	31	9	5.1	57
ULN (Urban)			1760	NG	NG	NG	NG	NG	6	50	7	3000	NG	NG	NG	13	200	NG	NG	300

Concentrations in bold and underlined exceed the urban ULN (or rural ULN where an urban guideline is not available NG - no guideline nd - no data

DL - detection limit

T - trace amount, interpret with caution

Table 3: Concentrations of elements in moss bags collected in the vicinity of Benn Iron and Eaton-Yale, Wallaceburg (December 1994).

Site	DISTANCE (m) and DIRECTION (approx.)		Inorganic Elements in Moss Bags (µg/g)																
			Al	Ba	Ba	B	Ca	Cd	Co	Cu	Cr	Fe	Mg	Mn	Mo	Ni	Pb	Sr	V	Zn
22	25 m	N	1300	DL	39	7.2	8750	0.30T	0.80T	12	3.4	1900	1050	170	0.49T	4.5	20	18	5.7	120
16	100 m	N	1450	DL	40	8.4	12500	0.37T	0.94T	23	5.0	2250	1200	165	0.58T	7.2	23	21	8.0	225
11	225 m	N	1300	DL	37	11	12000	0.58T	0.84T	29	4.1	1650	1200	140	0.86T	8.7	29	20	9.4	190
7	300 m	N	1350	DL	38	8.7	9050	0.27T	0.58T	10	4.1	1350	1250	155	0.06T	7.3	28	17	7.8	99
3	800 m	N	1400	DL	37	27.5	12000	0.39T	0.72T	25	3.8	1550	1350	180	0.61T	7.8	29	18	9.1	165
1	1000 m	N	1350	DL	38	8.7	9050	0.27T	0.58T	10	4.1	1350	1250	155	0.80T	7.3	28	17	7.8	99
8	350 m	NNE	1150	DL	45	8.2	5550	0.47T	0.86T	11	2.9T	1350	1040	190	0.50T	5.3	27	13	8.3	135
17	100 m	NE	1700	DL	39	6.8	8700	0.31T	0.86T	9	4.0	2650	1100	175	0.49T	5.7	21	19	6.8	155
18	200 m	NE	1500	DL	33	6.5	5550	0.25T	0.76T	9	3.2	1900	1150	240	0.44T	4.5	13	17	5.4	110
12	250 m	NE	1450	DL	37	6.6	4250	0.33T	0.80T	8	3.4	1860	980	185	0.39T	5.2	30	14	6.6	125
13	350 m	NE	1400	DL	37	4.7T	3450	0.32T	0.57T	8	2.9	1250	815	170	0.25T	4.1	27	12	6.8	89
9	450 m	NE	1100	DL	31	6.8	5600	0.47T	0.80T	10	2.4T	1200	1000	150	0.34T	7.8	33	12	7.8	275
2	900 m	NE	1350	DL	33	3.2T	2400	0.41T	0.61T	5	2.5	1400	875	190	0.22T	3.0	38	8	8.8	54
14	350 m	ENE	1500	DL	38	8.1	8400	0.36T	0.65T	9	3.3	1550	1160	140	0.58T	5.8	24	18	7.9	105
24	75 m	E	1700	DL	37	7.4	8160	0.39T	1.03T	8	3.7	2450	1200	180	0.46T	6.3	30	21	7.3	210
25	150 m	E	1650	DL	37	8.5	5400	0.38T	1.05	9	3.7	**3200**	1000	155	0.55T	5.2	28	14	8.8	195
19	300 m	E	1350	DL	35	7.8	5800	0.32T	0.89T	8	3.0	1500	1015	125	0.43T	8.0	22	18	7.8	107
20	500 m	E	1160	DL	42	5T	3800	0.28T	0.54T	8	2.5T	1100	885	135	0.30T	4.0	23	13	6.3	89
21	900 m	E	1260	DL	42	8.4	8050	0.37T	0.89T	7	3.4	1300	1050	140	0.50T	5.0	23	16	7.2	84
26	350 m	ESE	1300	DL	37	5.8	6550	0.28T	0.58T	11	3.0	1450	980	160	0.34T	3.9	26	13	6.5	120
31	300 m	SE	1650	DL	40	7.5	9160	0.29T	0.85T	15	3.8	1900	1200	140	0.58T	5.1	25	20	7.2	250
32	450 m	SE	1300	DL	31	5.4	4960	0.35T	0.58T	17	3.2	1350	965	150	0.28T	4.2	32	12	7.5	330
37	600 m	SE	1050	DL	33	4.7T	4500	0.28T	0.60T	7	2.9	1200	830	118	0.40T	3.8	28	11	6.5	70
30	200 m	SSE	1700	DL	37	7.3	8650	0.51T	1.05	34	5.0	2400	1200	155	0.89T	8.8	33	18	7.3	**1035**
33	300 m	SSE	1350	DL	33	5.2	4400	0.33T	0.77T	10	3.2	1600	990	165	0.47T	7.3	23	15	7.8	116
36	400 m	SSE	1350	DL	35	8.7	5250	0.37T	0.87T	12	3.5	1450	1025	190	0.40T	5.2	28	12	8.8	95
40	900 m	SSE	1150	DL	45	6.4	4200	0.47T	0.63T	11	2.7	1300	940	145	0.45T	4.9	37	16	8.8	285
23	25 m	S	1550	DL	39	4.6T	5200	0.32T	0.72T	11	3.2	1700	1050	150	0.40T	4.1	28	17	6.2	116
29	100 m	S	1650	DL	38	5.5T	5950	0.32T	0.78T	12	3.8	2050	1100	170	0.41T	4.4	24	19	6.4	180
35	350 m	S	1350	DL	32	7.7	8400	0.40T	0.89T	23	3.4	1750	985	150	0.67T	5.8	28	15	9.8	140
39	675 m	S	1100	DL	35	8.2	4050	0.43T	0.65T	8	2.7	1250	960	145	0.58T	5.1	33	16	8.9	87
41	1000 m	S	1160	DL	38	4.5T	3100	0.22T	0.39T	5	2.5	1100	890	150	DL	3.0	22	11	8.0	50
28	1 200 m	SW	1550	DL	38	7.5	8200	0.38T	0.90T	13	4.3	1950	1150	160	0.53T	6.2	27	18	8.8	190
34	400 m	SW	1200	DL	35	8.5	6850	0.24T	0.67T	7	2.9	1300	970	165	0.51T	5.2	23	14	8.1	83
38	700 m	SW	1150	DL	37	7.2	3950	0.33T	0.93T	8	2.8	1200	945	145	0.50T	4.8	25	16	9.0	89
27	300 m	WSW	1550	DL	38	7.5	8200	0.39T	0.90T	13	4.3	1950	1150	160	0.53T	6.2	27	18	8.9	190
15	300 m	W	1200	DL	38	8.6	3850	0.40T	0.60T	7	3.3	1350	920	160	0.39T	5.0	20	14	6.7	77
10	250 m	NW	1150	DL	37	5.8	3750	0.37T	0.58T	7	2.5T	1150	960	155	0.37T	3.8	28	14	5.4	79
5	450 m	NW	970	DL	33	8.8	6000	0.43T	0.42T	8	2.8	1150	925	110	0.39T	5.8	32	16	8.4	50
4	700 m	NW	1100	DL	40	5.8	3050	0.33T	0.39T	8	2.2T	1200	920	195	0.32T	3.7	24	13	5.8	86
6	350 m	NNW	1460	DL	38	14.6	6300	0.45T	0.85T	11	3.8	1600	1200	170	0.53T	11.4	31	16	9.3	81
42	3000 m	S	1300	DL	43	5.2	4250	0.43 T	0.51T	6	2.8	1300	950	150	0.2 T	5.9	28	15	9.1	85
43	8000 m	S	1450	DL	40	8.1	4350	0.49 T	0.50T	8	2.9	1350	995	120	DL	4.3	35	17	7.8	73
BLANKS			1140	DL	37	2.4T	2350	0.52 T	0.64 T	4	2.3T	1100	775	170	DL	2.8	23	10	5.8	57
ULN (Urban)			1700	NG	NG	NG	NG	NG	6	50	7	3000	NG	NG	NG	13	200	NG	NG	800

Concentrations in bold and underlined exceed the urben ULN (or rural ULN where an urben guideline is not aveilable. NG - no guideline nd - no data

DL - detection limit

T - trace amount, interpret with caution

Figure 1: Sketch map of moss bag stations in the vicinity of Benn Iron and Eaton Yale, Wallaceburg (1994).

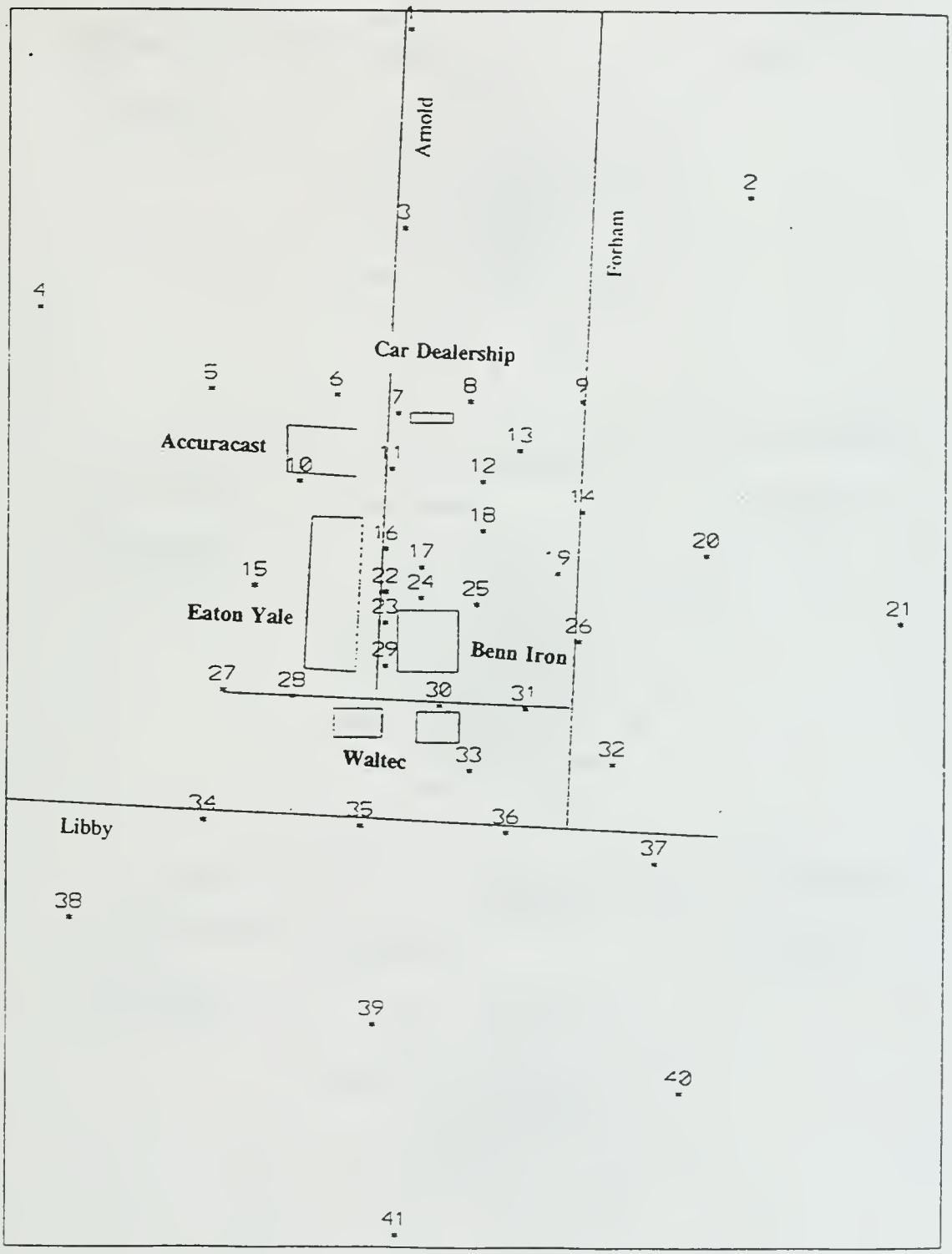
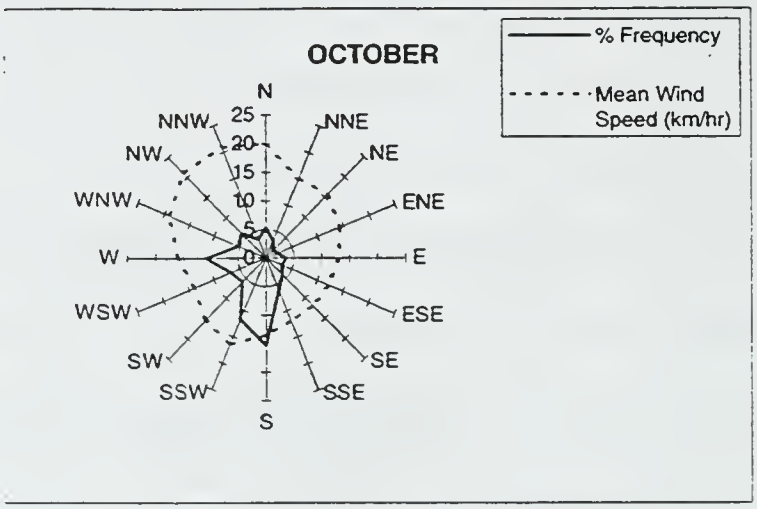
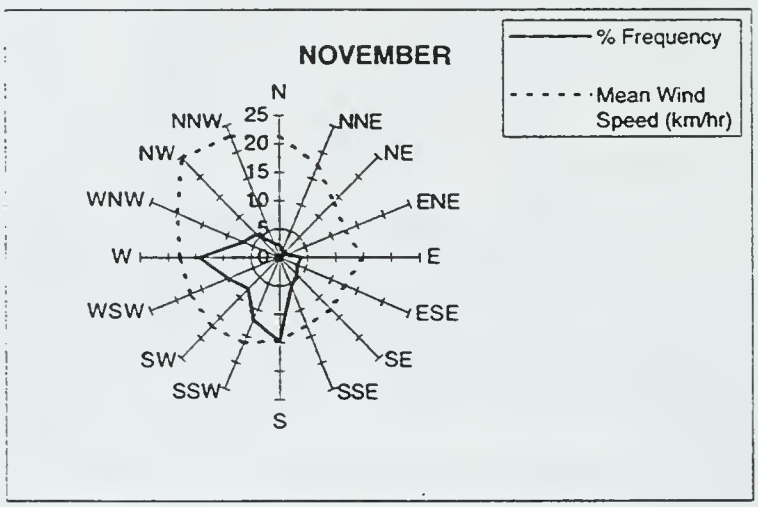


Figure 2: Wind Direction and Wind Speed Normals for the Sarnia Airport for the Months of October, November and December (1967-1980).





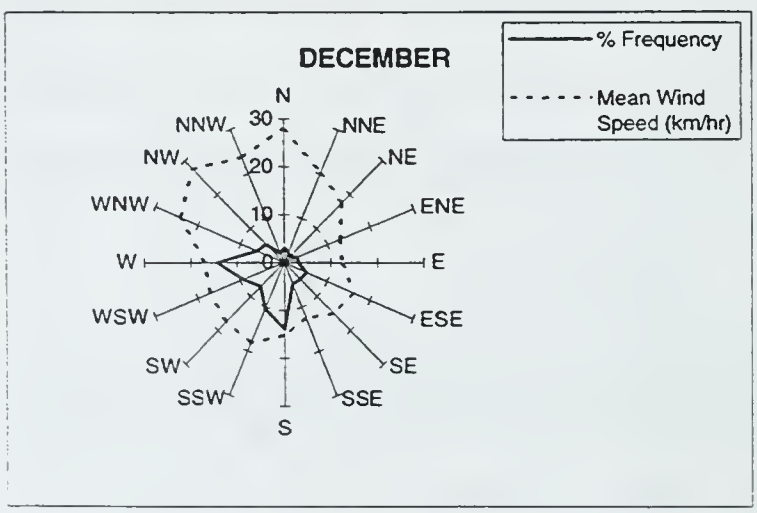
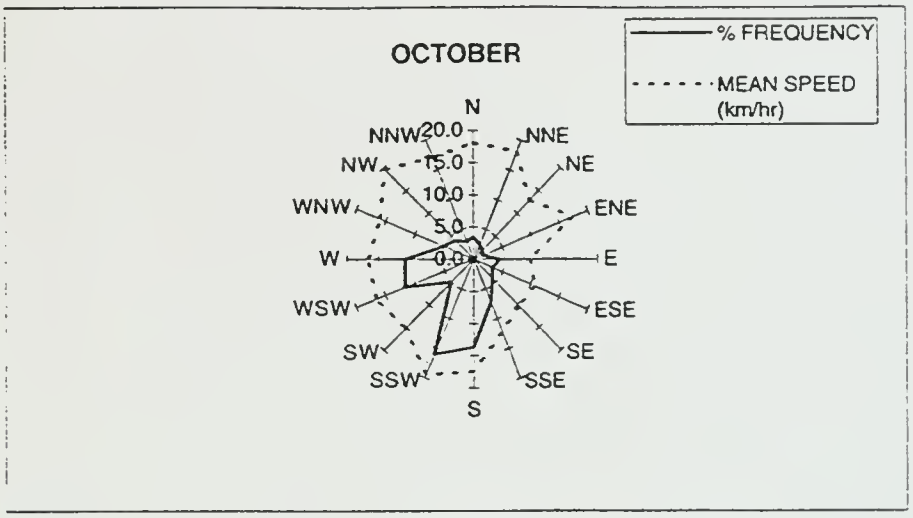
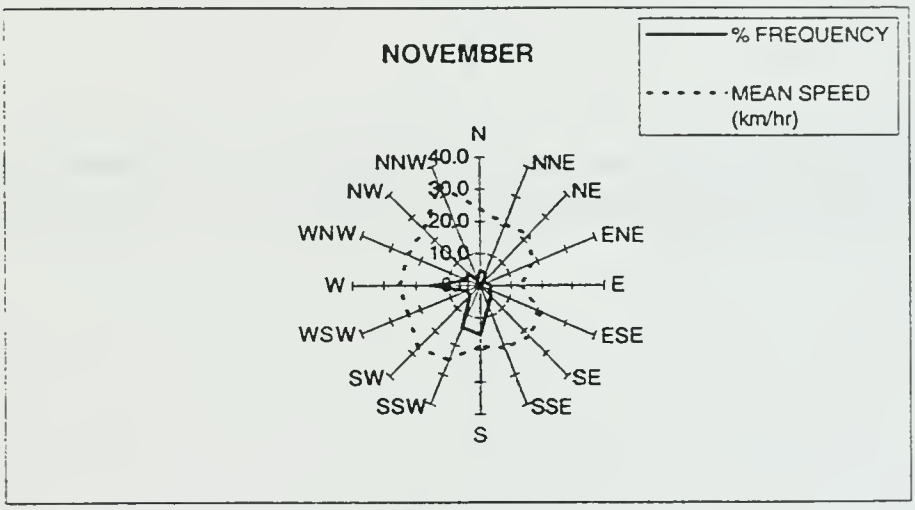
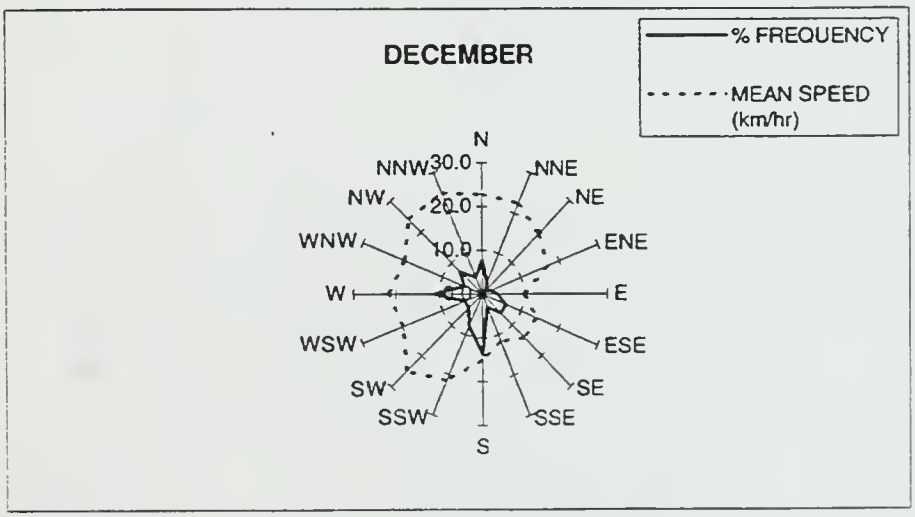


Figure 3: Wind Direction and Wind Speeds for Sarnia Airport during the October, November and December (1994) Moss Bag Collection Periods.







Concentration Contour Maps of Various Elements in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

Figure 4: Concentration Contour Maps of Aluminum in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994).

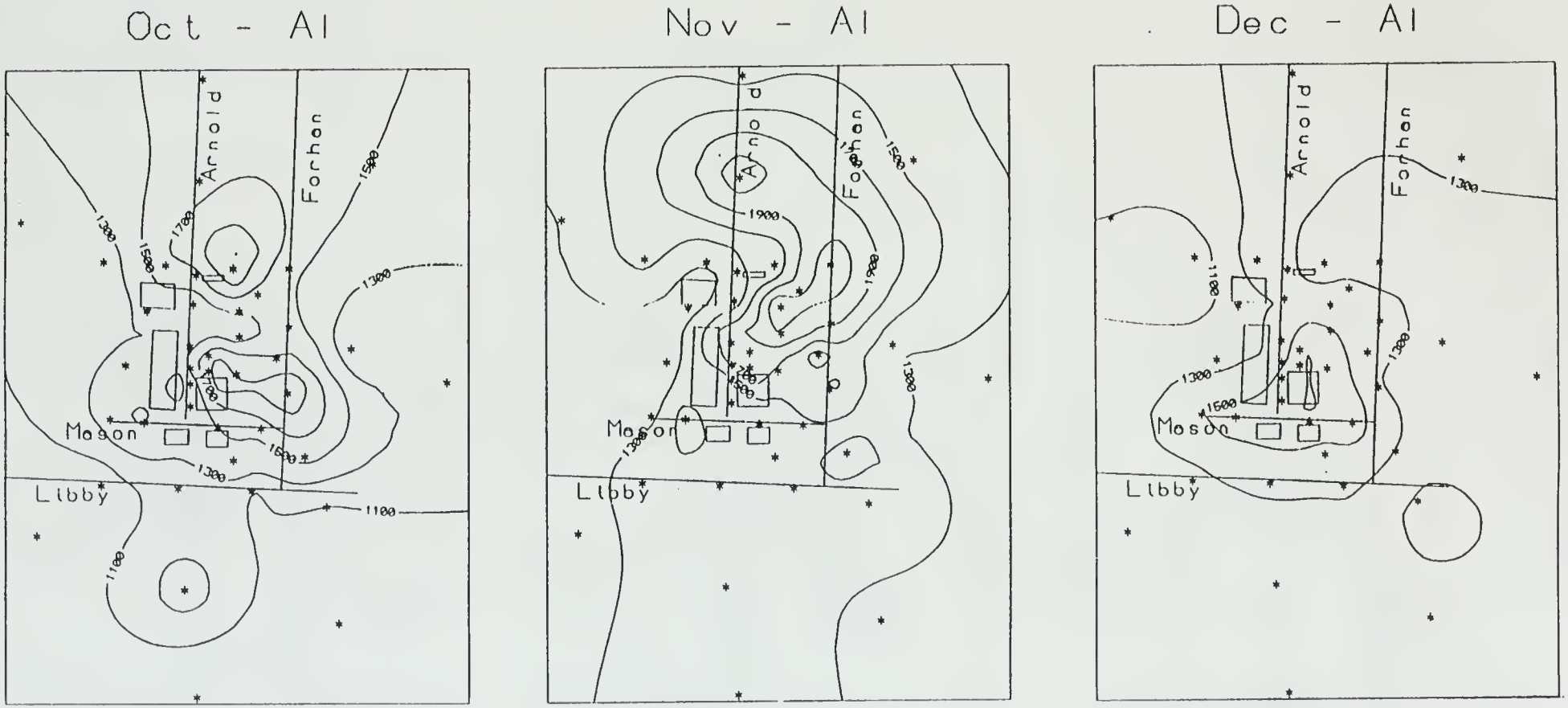
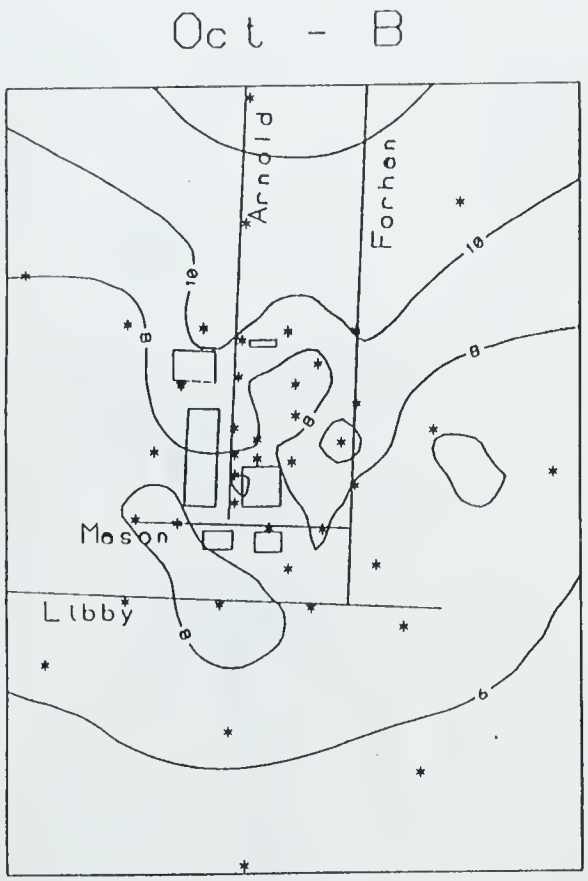
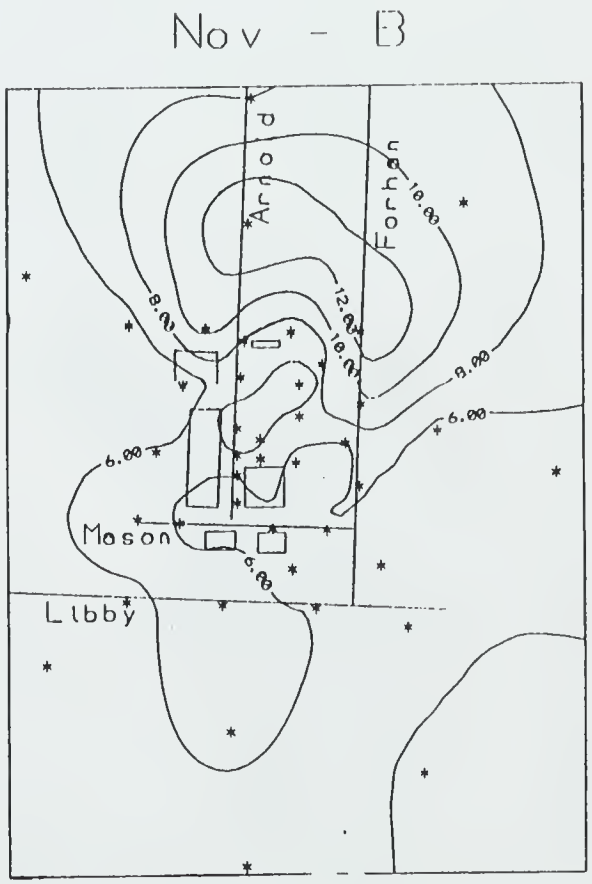


Figure 5: Concentration Contour Maps of Boron in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994).





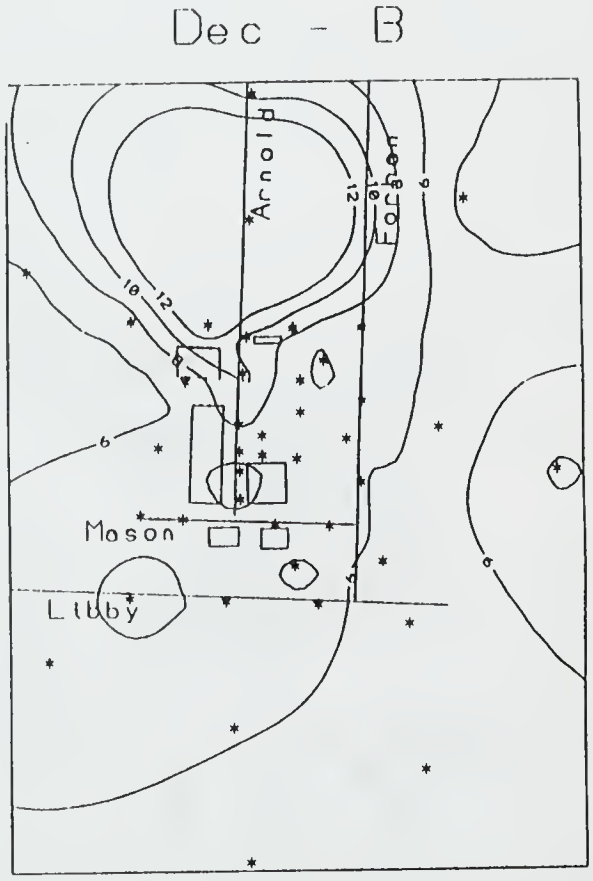


Figure 6: Concentration Contour Maps of Barium in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994).

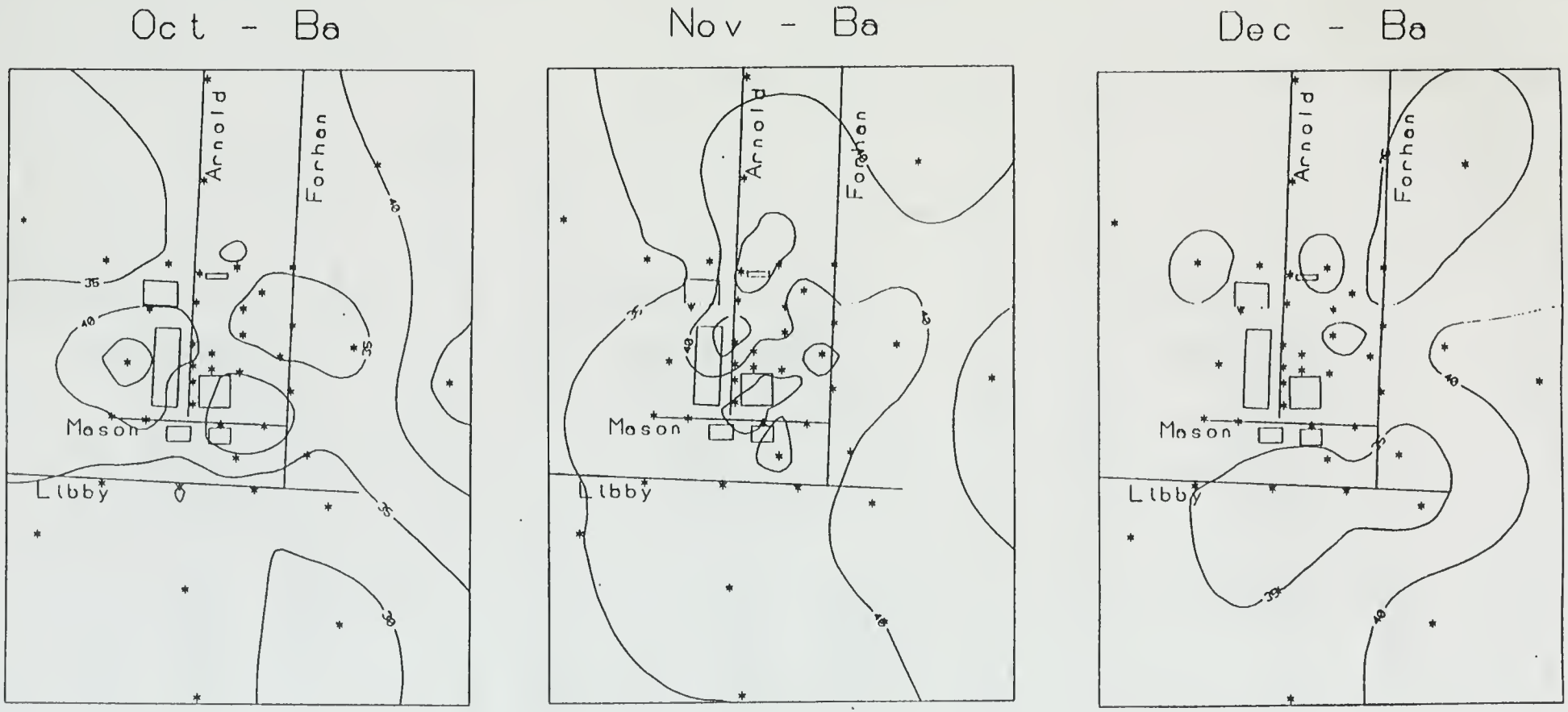


Figure 7: Concentration Contour Maps of Calcium in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

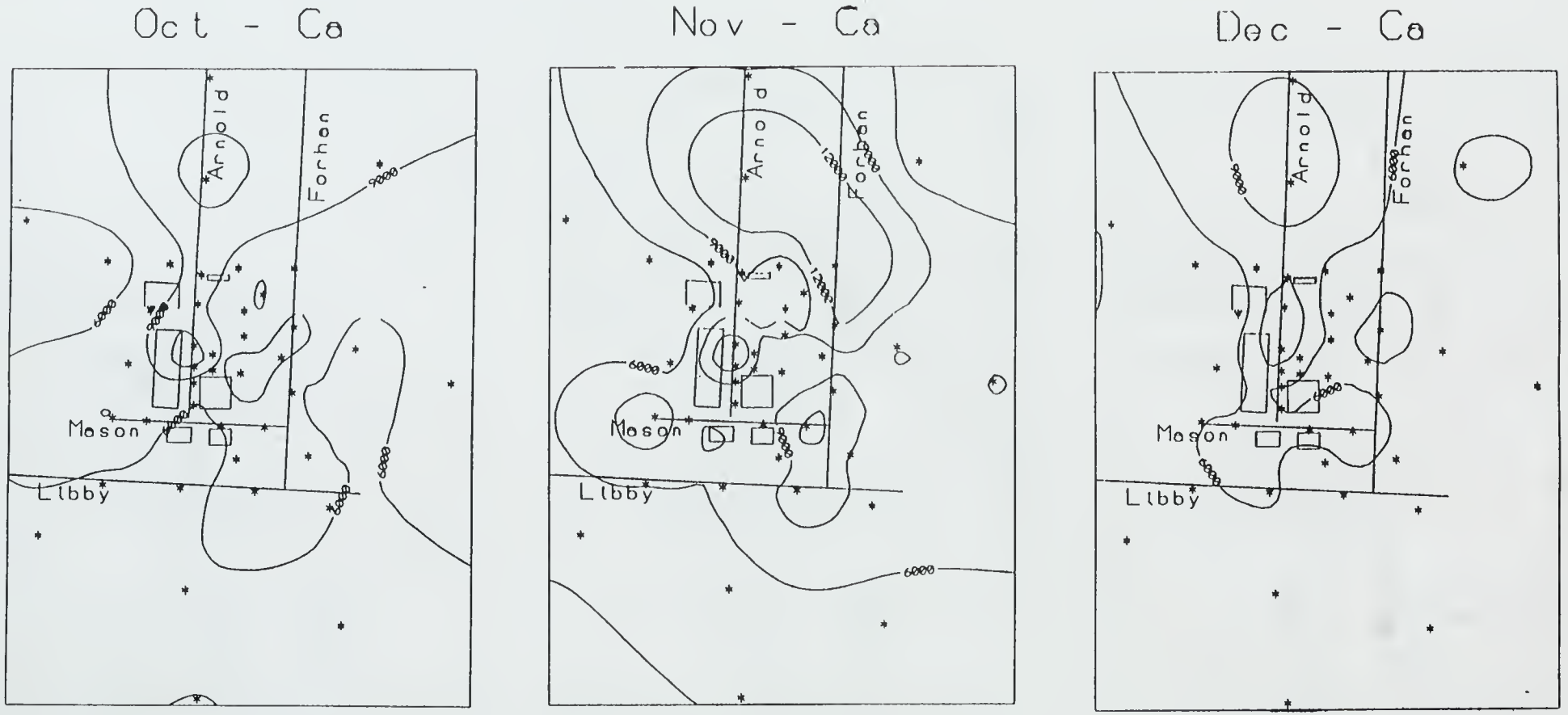


Figure 8: Concentration Contour Maps of Cadmium in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

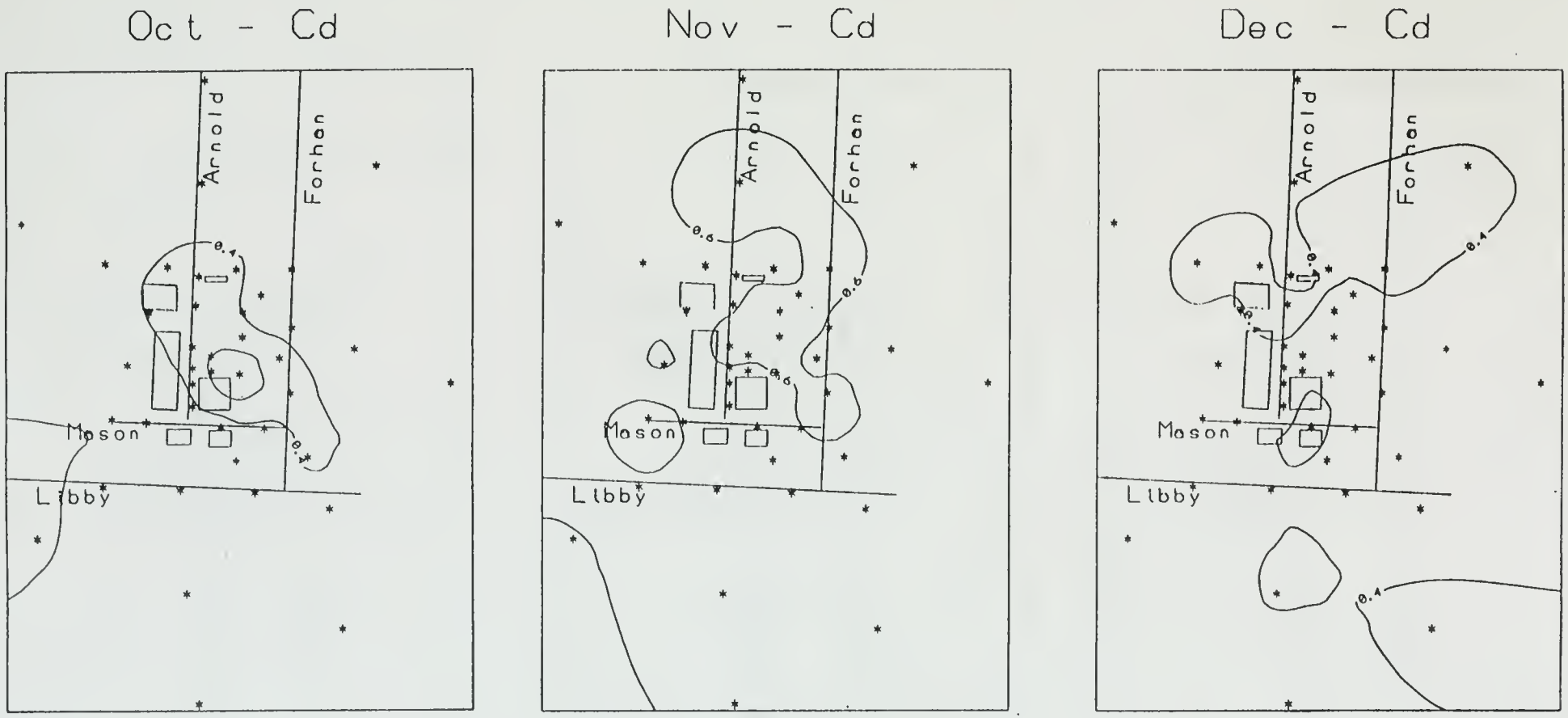


Figure 9: Concentration Contour Maps of Cobalt in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

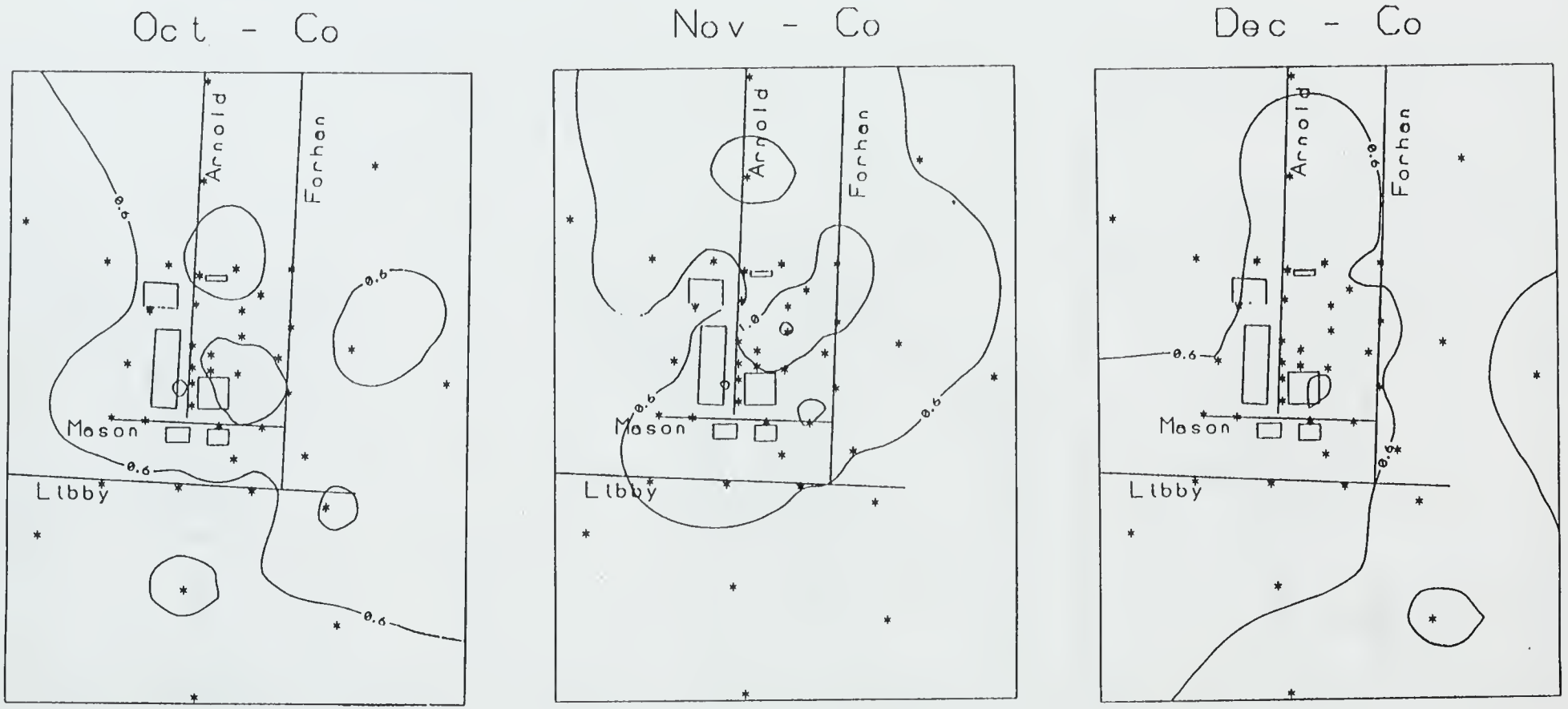


Figure 10: Concentration Contour Maps of Copper in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

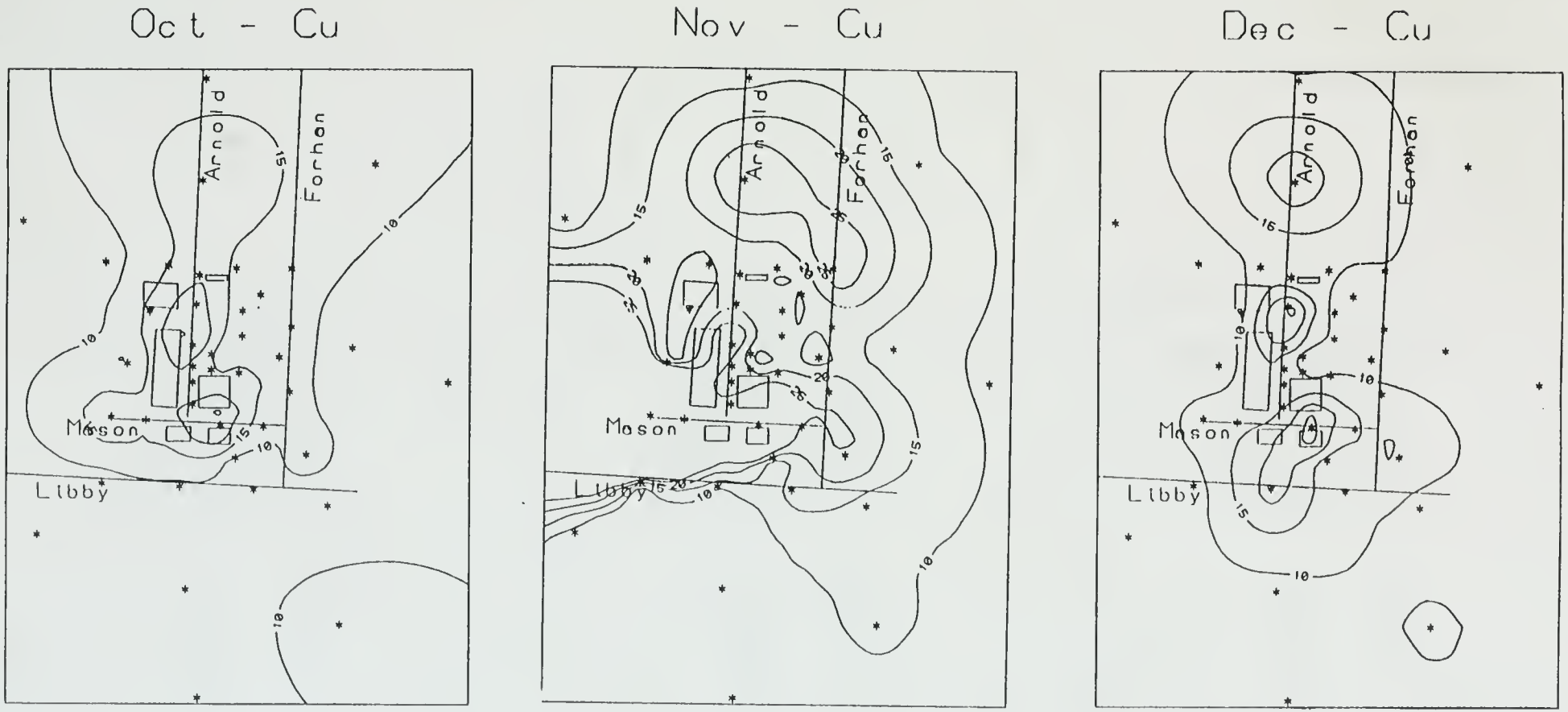


Figure 11: Concentration Contour Maps of Chromium in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

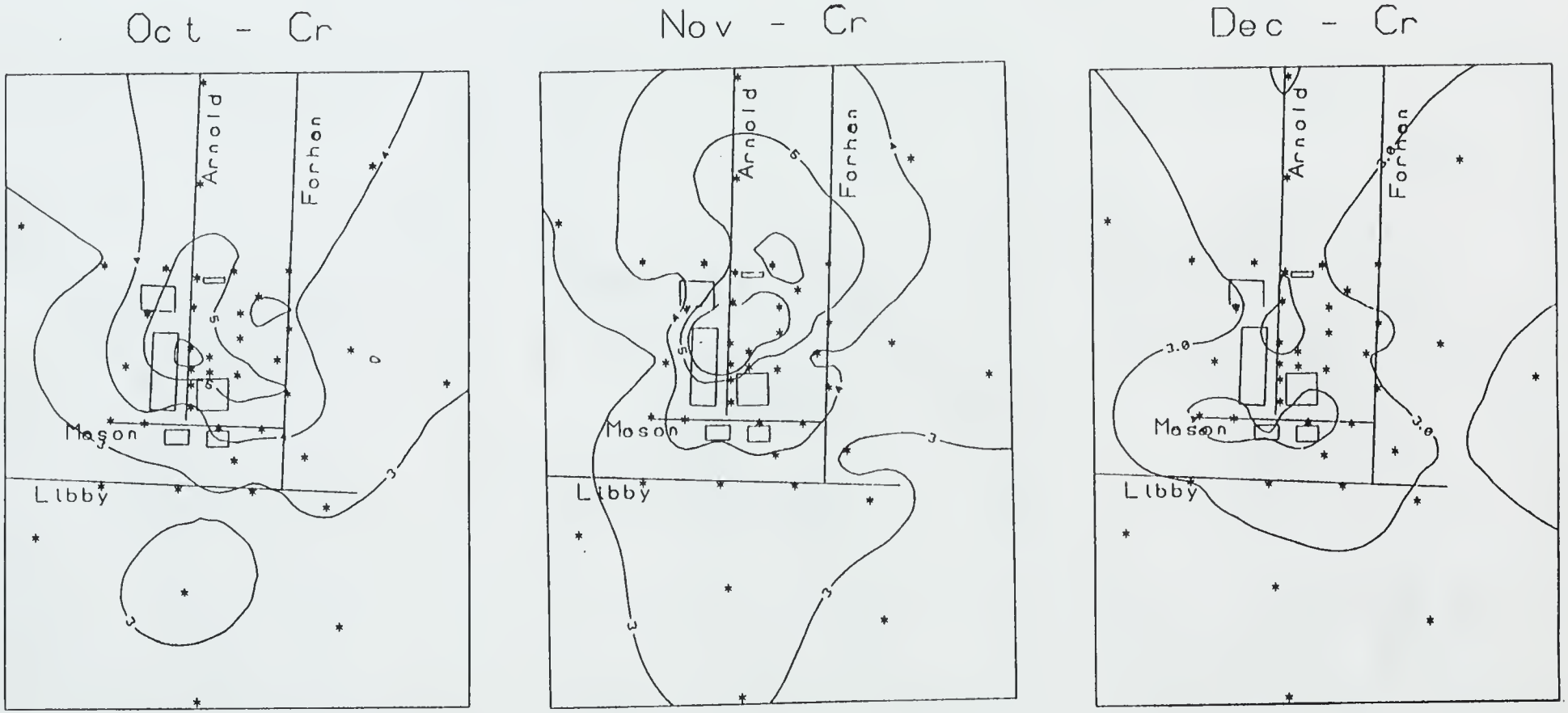


Figure 12: Concentration Contour Maps of Iron in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

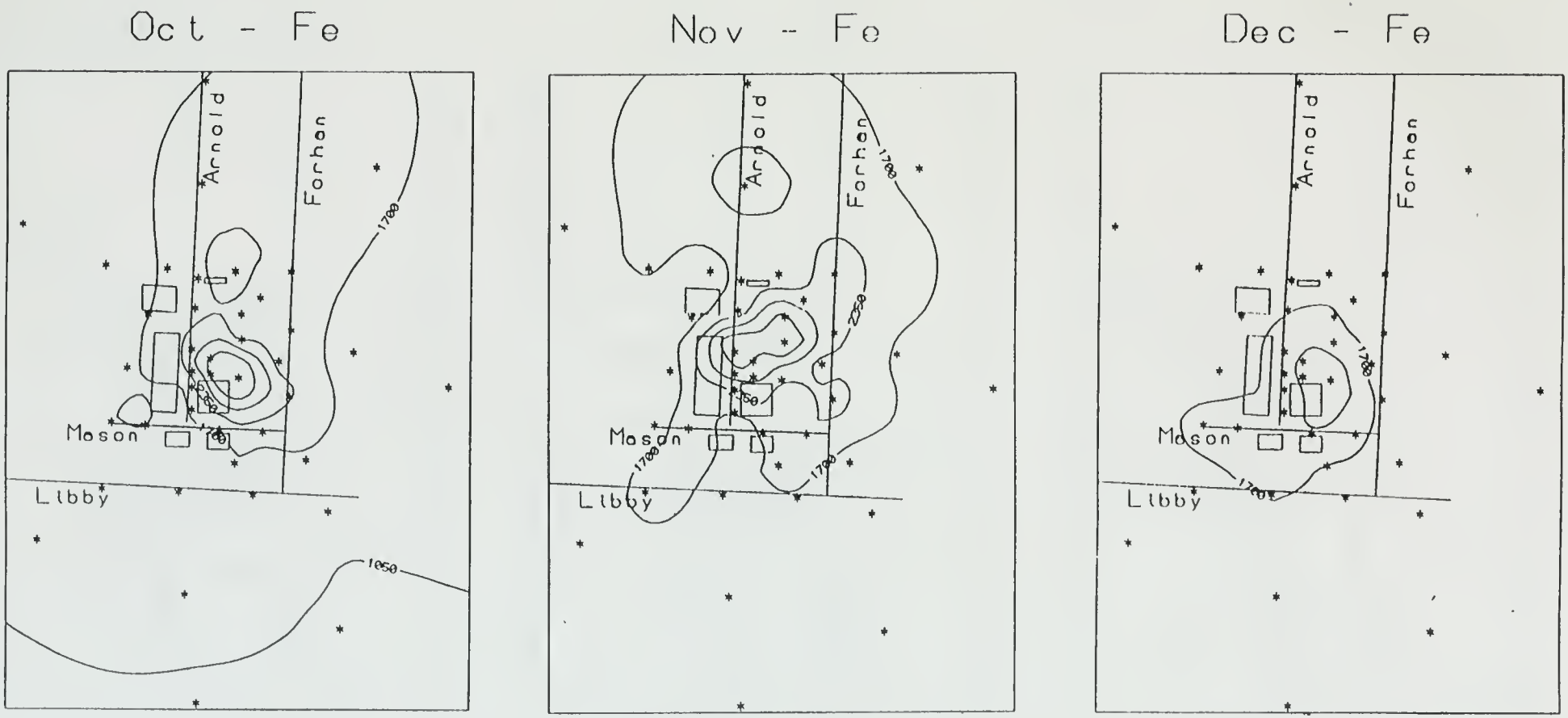


Figure 13: Concentration Contour Maps of Magnesium in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

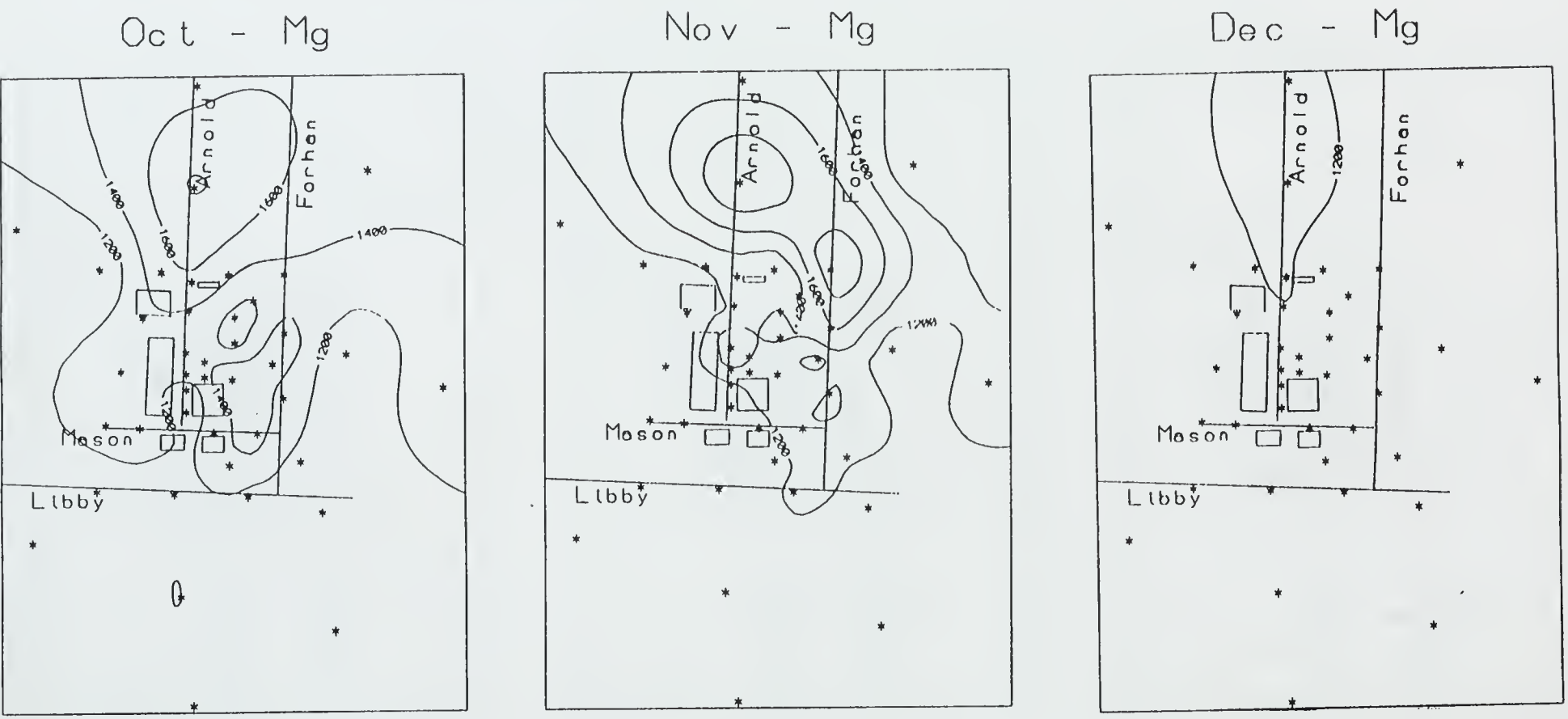


Figure 14: Concentration Contour Maps of Manganese in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

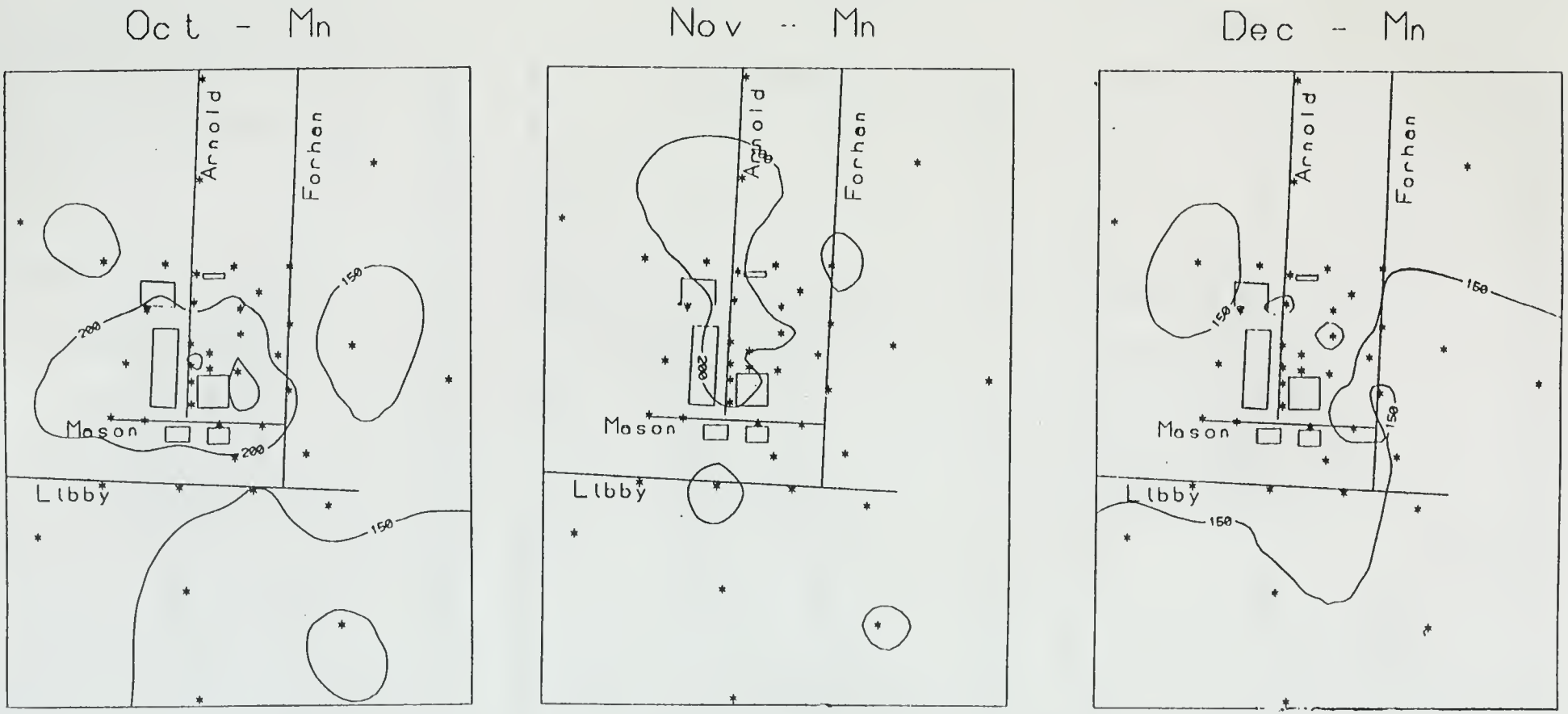


Figure 15: Concentration Contour Maps of Molydenum in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

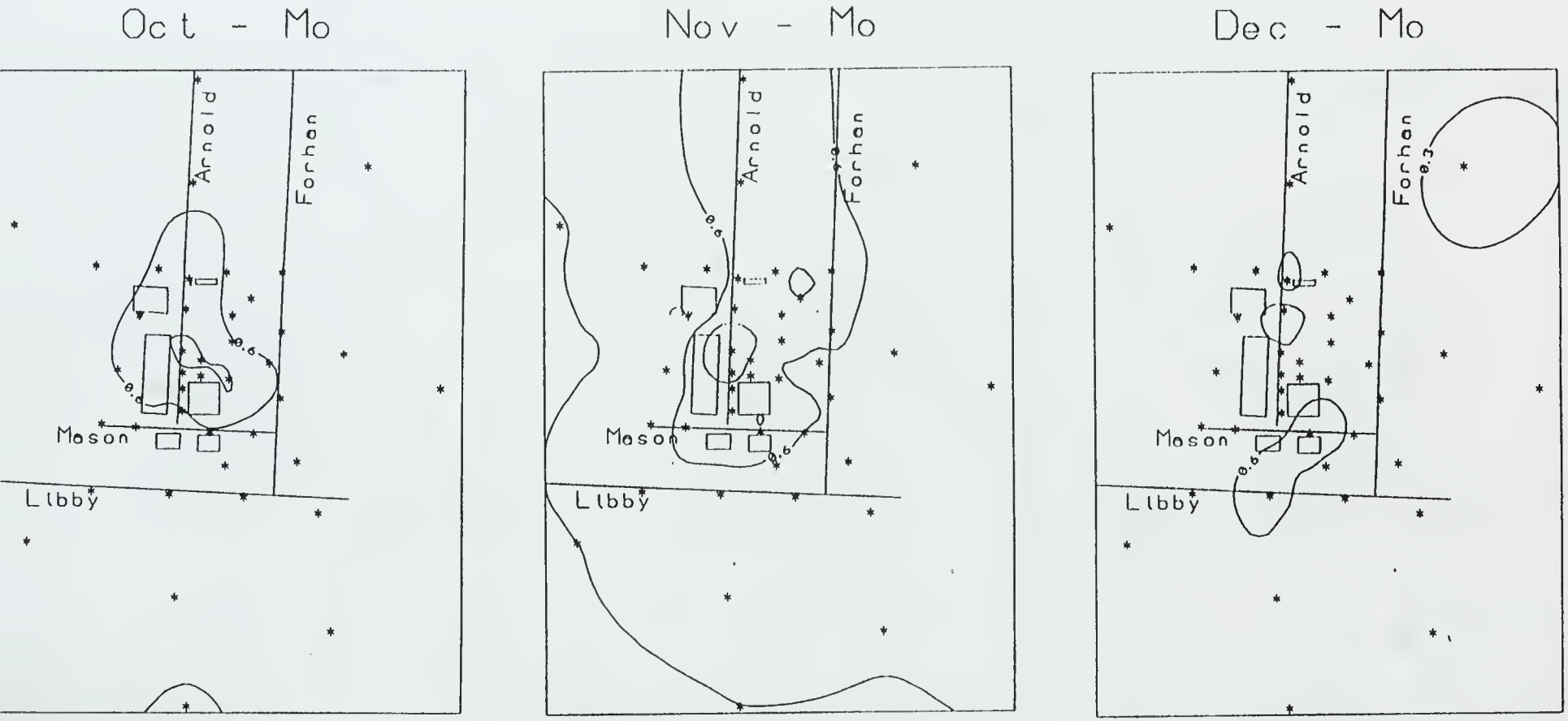


Figure 16: Concentration Contour Maps of Nickel in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

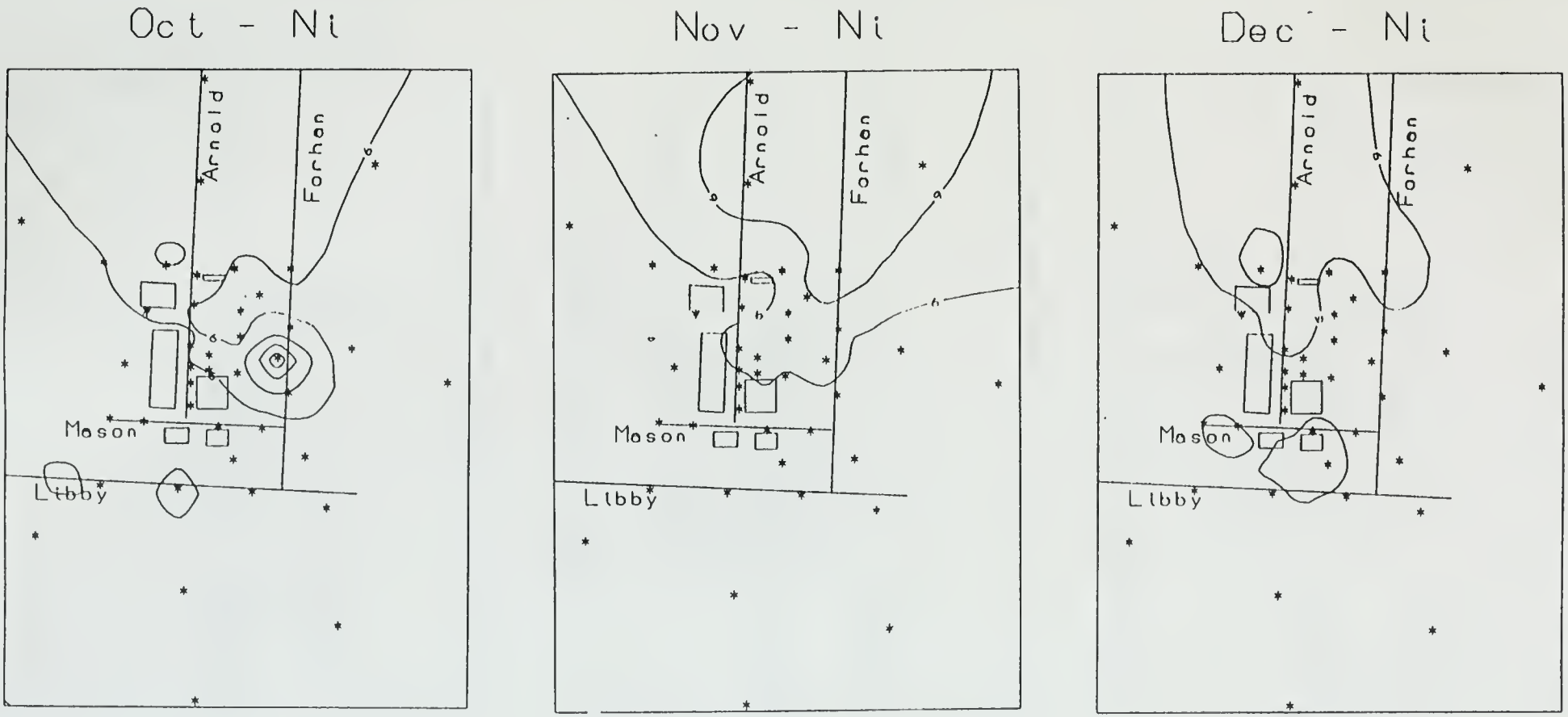


Figure 17: Concentration Contour Maps of Lead in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

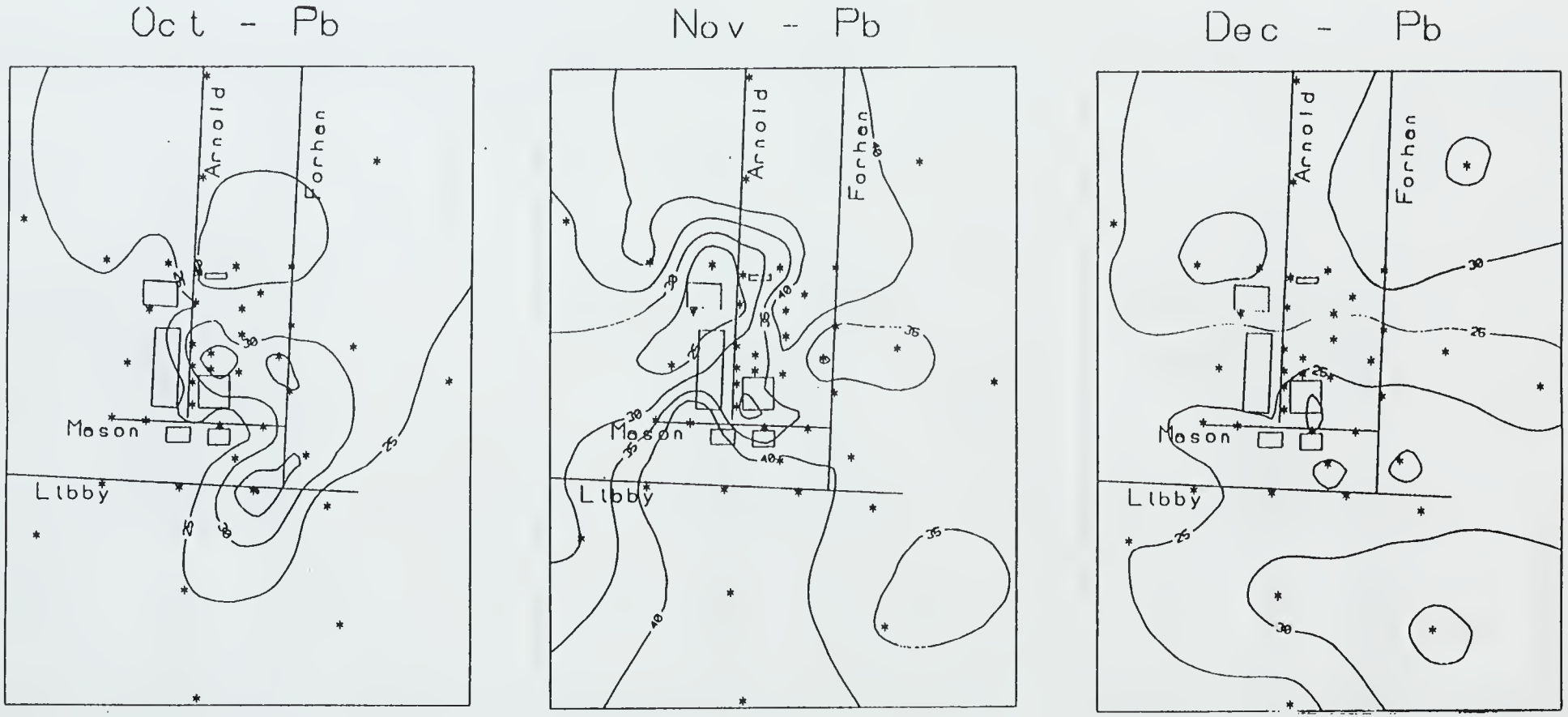


Figure 18: Concentration Contour Maps of Strontium in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

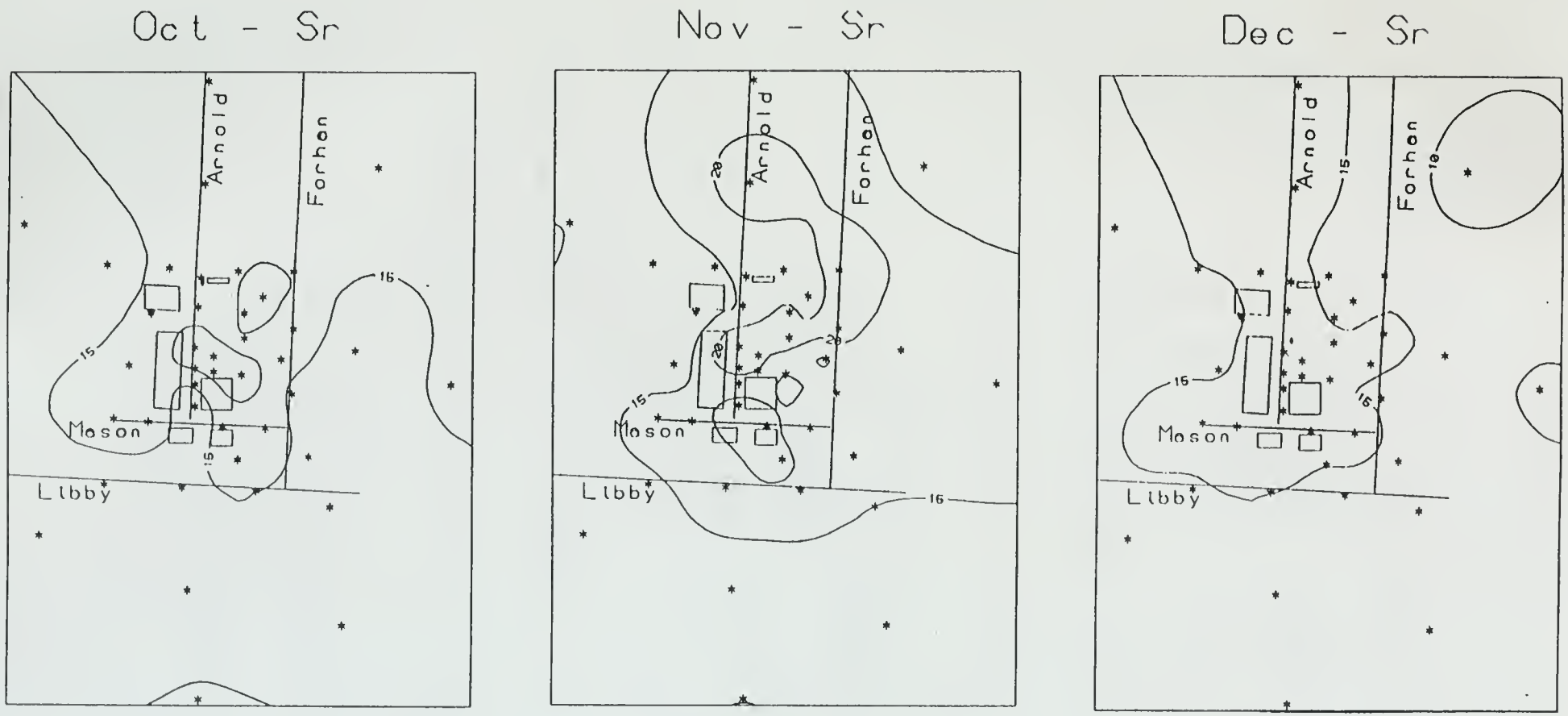


Figure 19: Concentration Contour Maps of Vanadium in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)

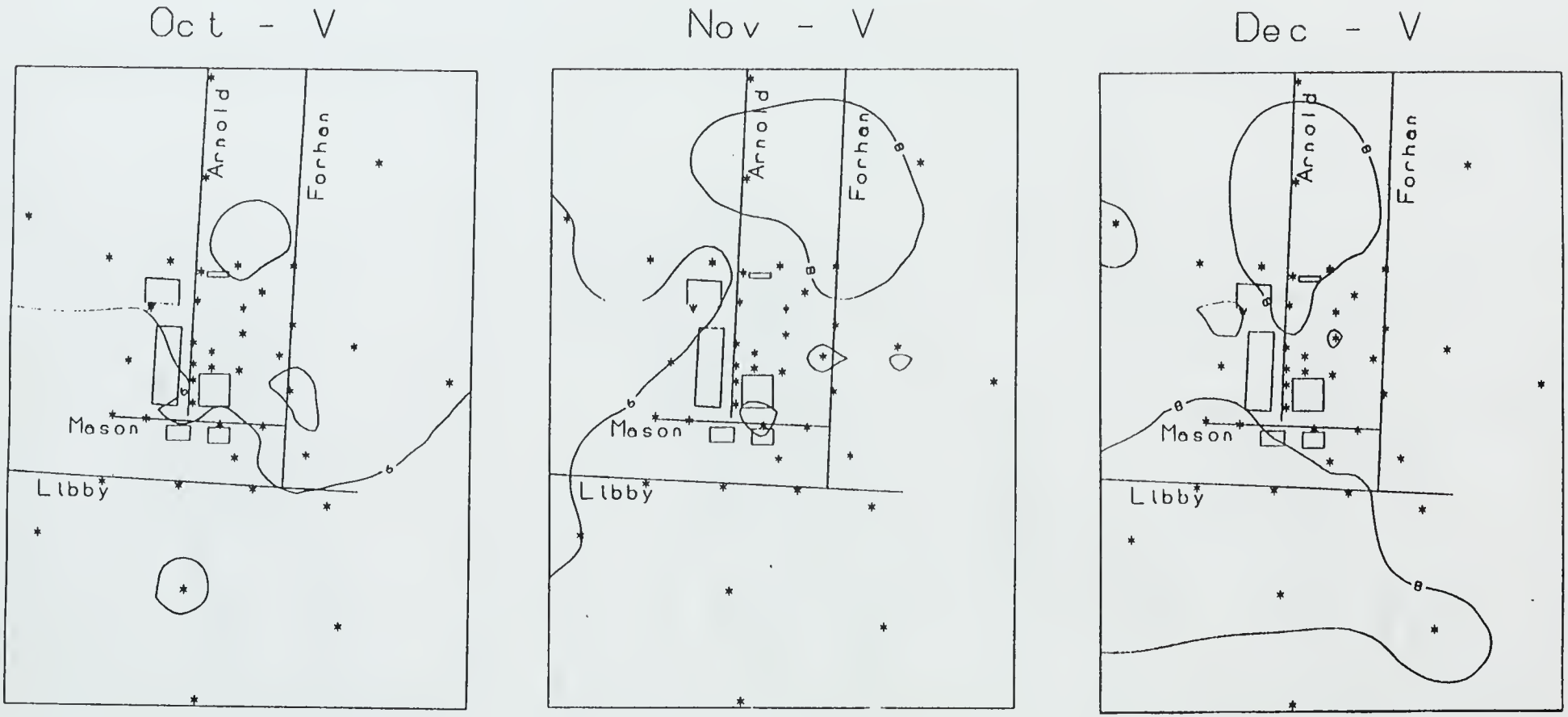
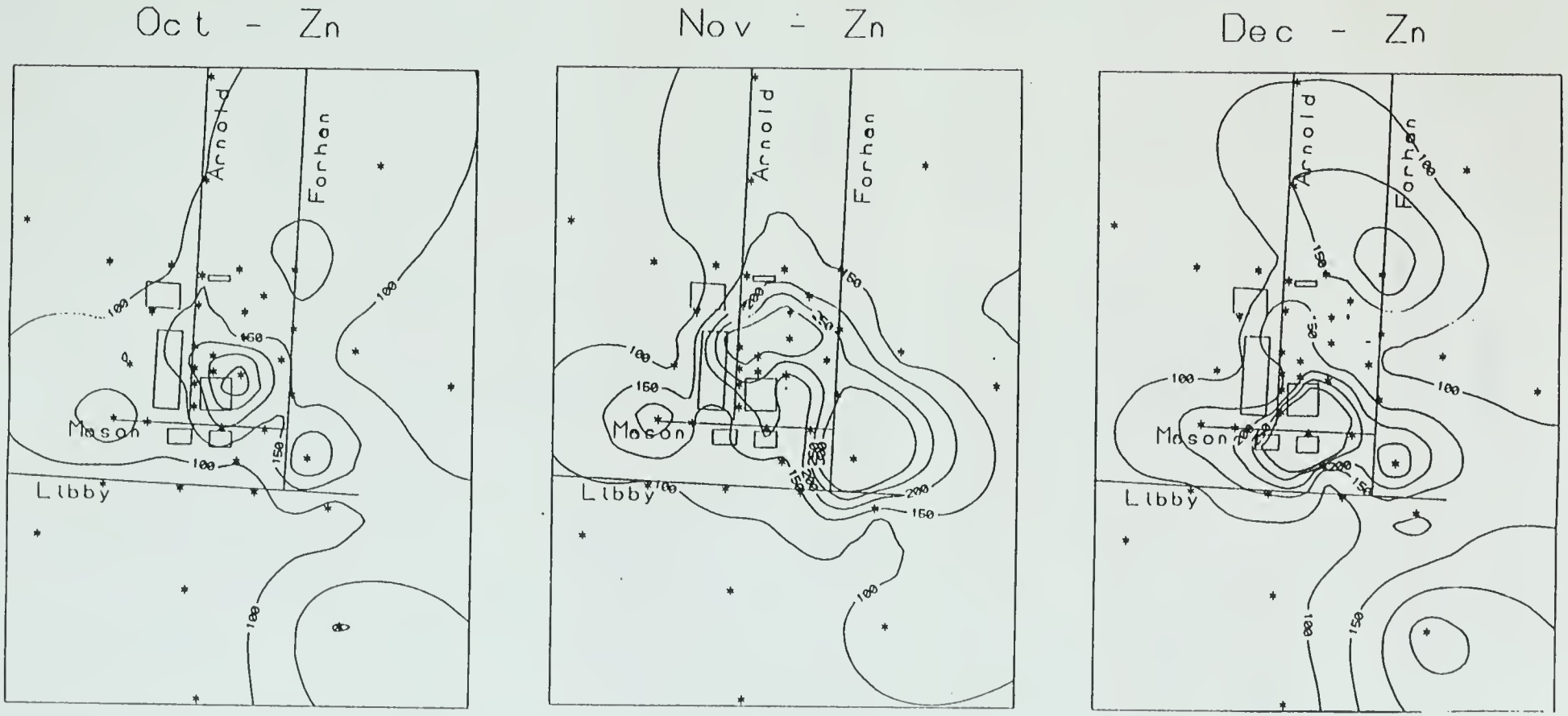


Figure 20: Concentration Contour Maps of Zinc in Moss Bags Collected in the Vicinity of Benn Iron and Eaton-Yale, Wallaceburg (October 1994)



APPENDIX

Derivation and Significance of the MOEE Phytotoxicology
"Upper Limits of Normal" Contaminant Guidelines.

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a point source of pollution. Urban ULN guidelines are based on samples collected from developed urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (ref: Ontario Ministry of the Environment 1983, Phytotoxicology Field Investigation Manual). Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean, plus three standard deviations of the mean, of the suitable background data. This represents 99% of the sample population. This means that for every 100 samples which have not been exposed to a point source of pollution, 99 will fall within the ULN.

The ULN do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULN are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULN are not known to be toxic.

ULN are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULN. The MOEE Phytotoxicology ULN are constantly being reviewed as the background environmental data base is expanded. This will result in more ULN being established and may amend existing ULN.